Fueling Our Future: Exploring Sustainable Energy Use - An Interdisciplinary Curriculum Recommended for Grades 9-12

Facing the Future, Western Washington University

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Exploring Sustainable Energy Use

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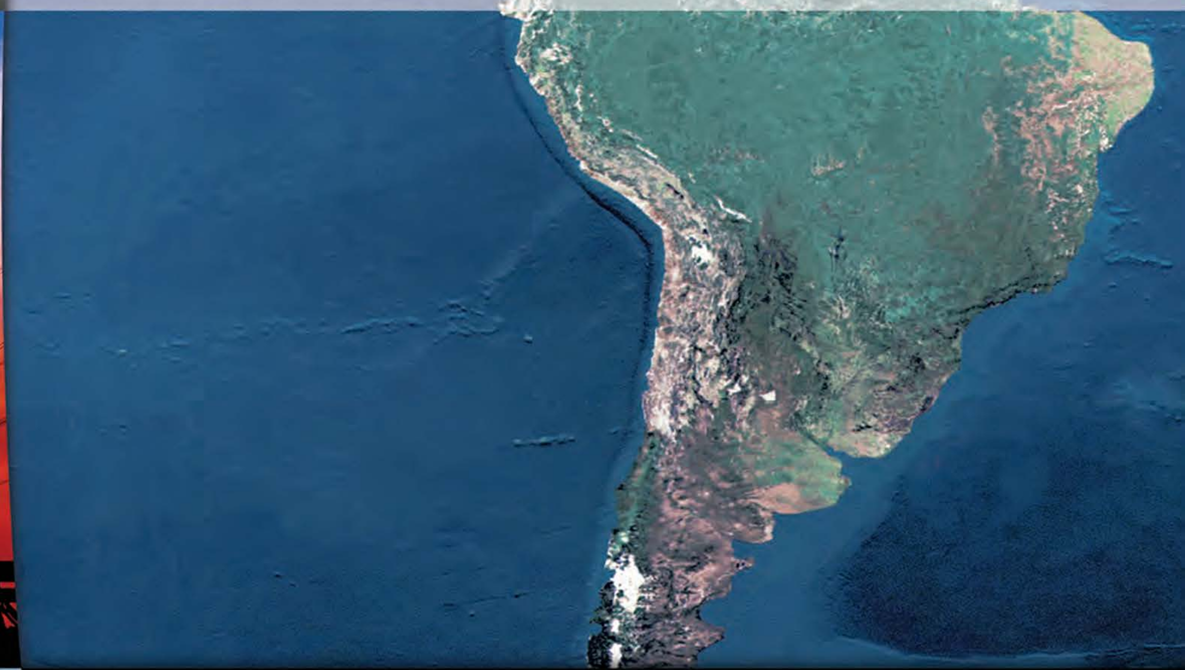

9–Lesson Curriculum Unit

Facing the Future

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Facing the Future

Fueling Our Future:
Exploring Sustainable Energy Use

Facing the Future is a nonprofit organization whose mission is to create tools for educators that equip and motivate students to develop critical thinking skills, build global awareness, and engage in positive solutions for a sustainable future.

We develop and deliver standards-based hands-on lessons, student textbooks, curriculum units, and professional development opportunities for educators. Facing the Future curriculum is in use in all 50 U.S. states and over 140 countries by teachers and students in grades K-12, in undergraduate and graduate classes, and across multiple subject areas. Facing the Future reaches over 1,500,000 students through its programming.

ISBN: 978-0-9711005-7-2

For more information, visit www.facingthefuture.org.

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This work, as part of the Northwest Advanced Renewables Alliance (NARA), was supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

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Acknowledgements

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A special thanks to the staff and graduate students of University of Idaho's McCall Outdoor Science School (MOSS) and other members of the NARA Education Team for their collaboration in the development and field testing of this curriculum.

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Introduction

Energy fuels our lives. It sustains our bodies, powers our industries, lights our cities, charges our cell phones, and moves our cars. Energy is interconnected with a range of global issues from climate change to economic development and resource scarcity. Taking a close look at human energy use is a key part of working toward sustainable societies, economies, and environments.

The world's energy needs are currently supplied primarily by fossil fuels. As we deplete the planet's supply of these nonrenewable natural resources, we can expect competition for fossil fuels to increase and the cost of energy to rise, creating a cascade of impacts across global markets. This will touch us all, from the farmer whose machinery runs on fuel to the parent trying to put food on the table. At the same time, our dependence on fossil fuels has an environmental impact that grows larger every day. The Intergovernmental Panel on Climate Change has stated that the burning of fossil fuels is the main contributor to increased atmospheric concentrations of carbon dioxide in the past century,[1] leading to global climate change. In the 21st century, challenges posed by the rapid depletion of fossil fuels and the contribution of carbon dioxide emissions to climate change have already begun to spur the development of alternative energy sources and new technologies and impel us to reexamine how we use energy.

Because energy consumption is deeply rooted in many local and global issues, the choices we make about energy can be part of sustainable solutions to critical challenges facing the world today. Such solutions can range from promoting home energy efficiency and conservation in order to lower household energy bills to using leapfrog technology to help developing communities access energy through the use of renewable resources. *Fueling Our Future: Exploring Sustainable Energy Use* presents an opportunity for you to engage your students in a relevant and authentic exploration of sustainable energy use. The unit asks students to reflect on how energy is connected to their own lives and to investigate paths toward energy systems that ensure access to energy for all people for generations to come.

Just as energy is an interdisciplinary topic, so too is this unit. During the first week, students review basic energy science, calculate their daily electricity use, read nonfiction text to identify the pros and cons of renewable and nonrenewable sources of energy, and analyze statistics on energy


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use around the world. During the second week, students embark on an in-depth study of transportation fuels. Using Facing the Future's global sustainability framework, students explore the social, economic, and environmental impacts of petroleum-based fuels and various biofuels. They do this by comparing the impacts of fuels throughout their supply chain, taking multiple perspectives, and proposing sustainable solutions. The lessons presented in this unit are student-centered, support critical thinking, and foster collaboration among students.

In addition to nine fully planned lessons, this curricular unit includes readings, formative and summative assessments, extensions, and service learning ideas. Readings include vocabulary, youth profiles, career profiles, case studies, and questions that check for student understanding. While formative assessments vary throughout the unit, each lesson is guided by inquiry and critical thinking questions and concludes with discussion questions. The unit also includes a pre and post assessment designed to show student growth in content knowledge, ability to analyze complex energy issues, and personal attitude toward energy consumption and energy resources. The last three lessons of this curriculum are designed as a context-specific performance-based assessment in which students conduct research on the timely real world issue of aviation biofuels. Students are authentically assessed on products such as posters, papers, and negotiations that help them to answer the performance-based assessment's driving question: What are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation?

By engaging youth with authentic and relevant activities to explore energy issues, we foster the understanding and critical thinking skills needed to make thoughtful personal and collective decisions about energy. We hope that *Fueling Our Future: Exploring Sustainable Energy Use* helps prepare students to navigate the complex real world issues of energy resources and consumption and motivates students to participate in positive energy solutions for a sustainable world.

Unit Overview

Fueling Our Future: Exploring Sustainable Energy Use begins with lessons that introduce students to foundational energy concepts. The lessons then begin to focus more specifically on topics like energy access and transportation fuels. The unit culminates with an aviation-focused performance-based assessment that is integrated into the final three lessons.

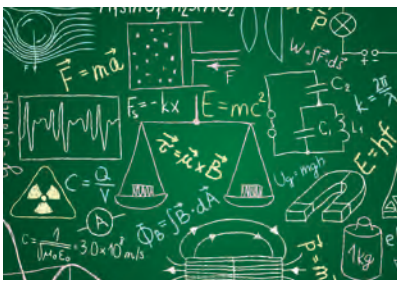
This unit was designed to contribute to the educational mission of the Northwest Advanced Renewables Alliance to strengthen the overall scientific literacy of students with respect to biofuels. The pre and post assessment can be administered before and after this unit to measure knowledge and personal attitudes about energy consumption.

Suggested Scope and Sequence

Introduction to Energy

Lesson 1: Energy 101

Students diagram energy transformations that take place with energy technology to demonstrate the law of conservation of energy.



Reading 1:
Introduction to Energy

Personal Energy Use

Lesson 2: Power to the People!

Students identify pros and cons of different nonrenewable and renewable energy sources used to generate electricity.

Reading 2:
Energy Today

Lesson 3: Lighten Up: A Personal Energy Audit

Students calculate their daily electricity use and identify behaviors and technology that can reduce their energy use.

Performance-based Assessment

Lesson 7: The Sky's the Limit

Students critically assess information from different multimedia resources to identify the motivation to shift from petroleum-based aviation fuels to alternative fuels.

Lesson 8: The Life of a Fuel

Students research the steps required to produce different biofuels and consider possible environmental impacts on the region.

Lesson 9: Sustainable Flight: A Stakeholder Meeting

Students represent stakeholder interests to negotiate a sustainable aviation biofuel mix for the Pacific Northwest.

Global Energy Use

Lesson 4: Toil for Oil

Students simulate the extraction of oil and analyze graphs depicting global oil consumption and reserves. Students then use an interactive timeline to examine the role of oil in U.S. history.

Reading 3:
Background on Energy

Lesson 5: Energizing the World

Students examine graphs and statistics to learn of the diverse energy needs of people around the world and propose sustainable energy solutions.

Reading 4:
Pathways to Progress: Energy

Transportation Fuels

Lesson 6: Fueling the Future

Students use multiple perspectives to evaluate the sustainability of extracting or growing different transportation fuel feedstocks.

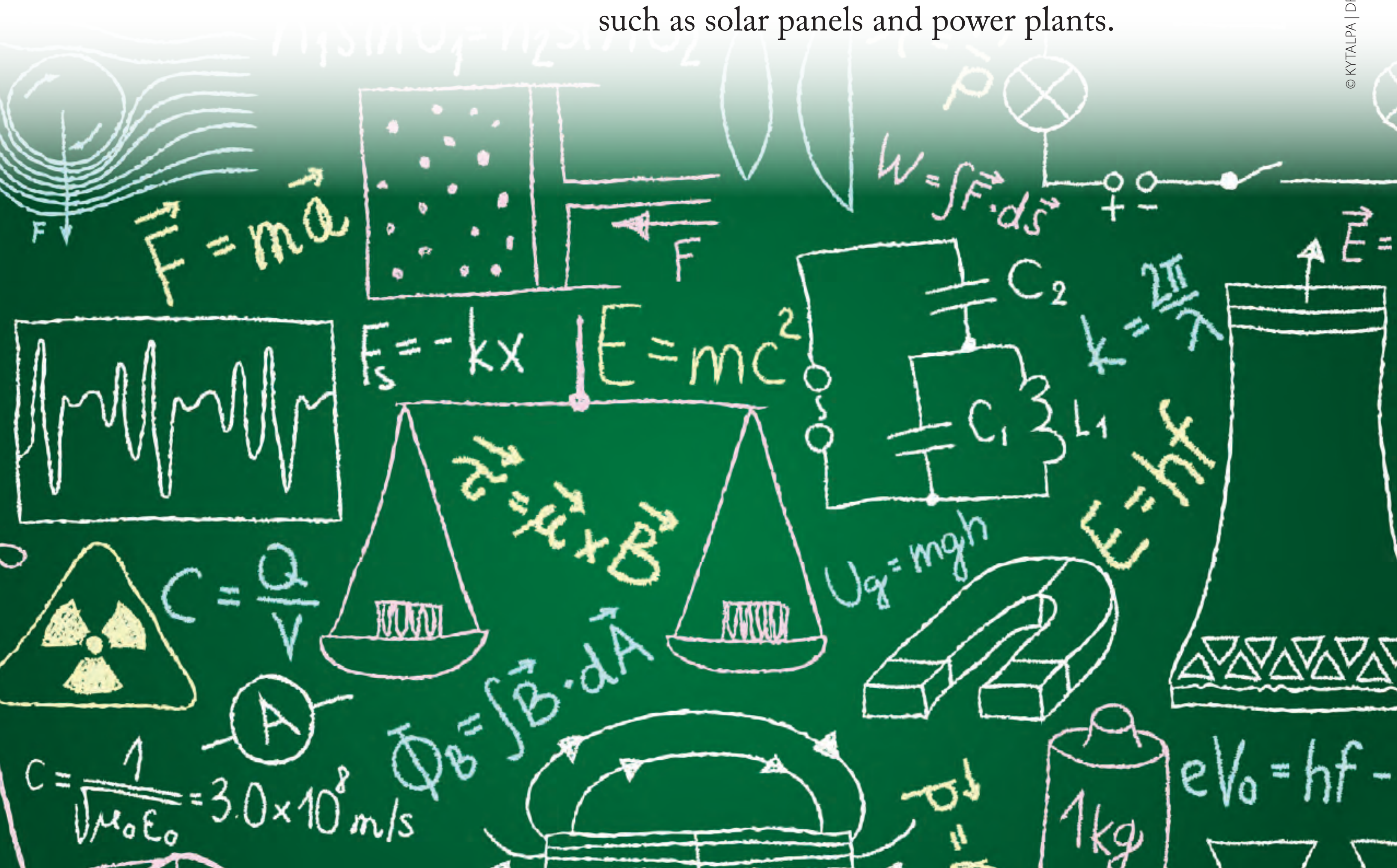
Standards Correlations

- *Fueling Our Future: Exploring Sustainable Energy Use* correlates to standards in all 50 U.S. states, including Common Core State Standards and the Next Generation Science Standards.
- Educators can visit our standards correlation tool at www.facingthefuture.org to see how this unit correlates to state standards.
- Each lesson has also been aligned to the fundamental concepts presented in *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education* (http://www1.eere.energy.gov/education/energy_literacy.html), created through collaboration between the U.S. Department of Energy, the American Association for the Advancement of Science, and thousands of experts.

Lesson 1

Energy 101

Students begin this unit of study by brainstorming and analyzing a list of ways we use energy. Students create a concept map to review the different forms of energy and the law of conservation of energy. They demonstrate understanding of these concepts by diagramming and explaining the energy transformations that take place during the use of energy technology such as solar panels and power plants.



DON BECKER, U.S. GEOLOGICAL SURVEY

Objectives

Students will:

- understand how energy is relevant to their lives
- classify forms of energy as potential or kinetic
- understand how the law of conservation of energy applies to energy technology
- analyze examples of energy transformation

Inquiry/Critical Thinking Questions

- How and why do humans use energy?
- What are everyday examples of energy transfer and transformation?
- How do the laws of nature limit energy-producing technologies?

Time Required

One 60-minute class

Key Concepts

- **energy**—The ability of a system to do work or cause change.
- **energy transfer**—The transfer of energy from one object to another.
- **energy transformation**—The conversion of energy from one form to another.
- **kinetic energy**—Working energy, or the energy of motion.
- **law of conservation of energy**—Energy cannot be created or destroyed, but it can be transferred or transformed.
- **potential energy**—Stored energy, or forms of energy (such as gravitational potential energy) that result from an object's position or relationship with another object.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

1.1 Energy is a quantity that is transferred from system to system.

1.3 Energy is neither created nor destroyed.

1.4 Energy available to do useful work decreases as it is transferred from system to system.

1.5 Energy comes in different forms and can be divided into categories.

1.6 Chemical and nuclear reactions involve transfer and transformation of energy.

Materials/Preparation

Overhead: *Just Add Energy!*

Example: *Energy Concept Map*

Handout: *Energy Cards*, 1 per small group, pre-cut before class

Handout: *Analyzing Energy Technology*, 1 per student

Optional: Incandescent light bulb and lamp


JEFFERSON S. ROGERS

Activity

Introduction

1. Tell students that today you will begin a unit on energy use and sustainability.
2. Give students 1 minute to write down as many ways they use energy as they can think of.
3. When time is up, compile student answers on the board.

   Note: You do not necessarily have to correct student answers at this point, but you may want to look for student misconceptions about energy and energy use.
4. Project the overhead *Just Add Energy!* for students to see and ask the class to compare the overhead list with the list they came up with.
5. Ask students whether their lists include activities that require energy such as extracting natural resources or manufacturing different products? Why or why not?
6. Now ask students to analyze the list and identify different categories of human energy use. In other words, could they group some of these specific uses of energy into larger categories (e.g., travel or transportation and basic human needs)? Use the following questions if students need some guidance:
   - Which activities represent your direct energy use (such as turning on a lamp) and which describe your indirect energy use (such as the gas used to transport the food you buy at the grocery store)?
   - Which activities help you to meet your basic human needs? Which help you beyond your basic human needs?
7. Have students partner with a neighbor to come up with at least 3 different ways of categorizing these uses of energy.
8. When partners are finished, ask students to share the different ways they categorized human energy consumption.
9. Share with the class how some organizations have categorized energy use. For example:
   - The U.S. Energy Information Administration often separates energy use into 4 main sectors: industrial, transportation, residential, and commercial.
   - The United Nations Secretary-General's Advisory Group on Energy and Climate Change has grouped energy use into 3 different levels of energy access based on the benefits provided at each level: 1) "Basic human needs," energy used for lighting, health, education, and communication; 2) "Productive uses," energy used for agriculture, commerce, and transport; and 3) "Modern society needs," energy used for home appliances, heating/cooling homes and water, and personal transportation.[1]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Steps

1. Tell the class that, as they just saw, we use energy to meet many of our needs and to provide comfort to our lives. In order to embark on a study of human energy use, it is important to first review some of the basic energy science that guides and constrains it.
2. Give each student a blank sheet of paper and let them know that today the class will create a concept map to record some basic energy science and agree upon the definitions you'll use for this unit.

   Note: This concept map can be a resource for each student to come back to throughout the unit. A sample concept map is provided for you at the end of this lesson.
3. Write the word "energy" in the middle of the board and have students do the same on a piece of paper. Ask if anyone can define this term.
4. Share with students the scientific definition of energy:
   - **energy**—The ability of a system to do work or cause change.
5. Remind students that there are many different forms of energy, and all can be classified as kinetic energy or potential energy (in some cases, forms can be both kinetic and potential). Add the words kinetic and potential to the concept map. Have students share definitions of these words and present the following definitions to the class:
   - **kinetic energy**—Working energy, or the energy of motion.
   - **potential energy**—Stored energy, or forms of energy (such as gravitational potential energy) that result from an object's position or relationship with another object.
6. Ask the class to brainstorm aloud specific forms of kinetic energy and potential energy and write their answers under the appropriate word on your map on the board. If students have a hard time coming up with forms of energy, then read from the following list and have students determine whether each form of energy is classified as kinetic or potential:
   - **electrical energy**—Energy carried by electrons (negatively charged particles found in atoms). If an electron is separated from an atom, it can move through wires and other materials that conduct electricity. Even air can be conductive. Lightning is an example of electrical energy moving through air. *(kinetic)*
   - **gravitational potential energy**—Energy stored in an object due to its height above Earth. The larger the mass of an object and the higher it is above Earth, the greater the gravitational potential energy of the object. *(potential)*


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- **thermal energy—**The internal energy of a system or substance caused by the random vibration of molecules. When a substance (such as water) is at a high temperature, the particles of that substance move faster and the substance has a greater amount of stored thermal energy. Friction is one source of thermal energy—just rub your hands together to feel it! *(kinetic)*
- **radiant energy—**Electromagnetic energy traveling in transverse waves. Some forms of radiant energy such as light are visible, while other forms such as infrared, ultraviolet, x-ray, gamma ray, and radio waves are not. *(kinetic)*
- **nuclear energy—**Energy stored within the nucleus of an atom. The force that holds together the nucleus of an atom is one of the strongest in the universe! This energy may be released when an atom is either split (fission) or fused with another atom (fusion). *(potential)*
- **chemical energy—**Energy stored in the bonds between atoms and molecules. Food and fuels are made up of chemicals that store energy in their bonds. Batteries, corn, petroleum, and wood all possess chemical energy. *(potential)*
- **motion energy—**Energy of a moving object. The faster an object moves, the more motion energy it has. A bike speeding down the street and an arrow flying through the air are both examples of motion energy. *(kinetic)*
- **sound energy—**Energy traveling by longitudinal waves through substances like air and water, causing them to vibrate. For example, when you speak air moves past your vocal cords, causing vibrations that make the sound you hear. *(kinetic)*
- **elastic energy—**Energy stored when an object is deformed such as stretching a rubber band or compressing a spring. *(potential)*

7. In Think-Pair-Share format, have students discuss where they have encountered these forms of energy in their own lives. If desired, students can include examples of objects that possess these different forms of energy on their concept maps.

8. Show the class a picture of an incandescent light bulb or plug in a lamp with an incandescent light bulb. Ask students what a light bulb is for *(to provide light)*. What form of energy is this? *(radiant energy)* Ask students what type of energy is needed in order for this machine to work *(electrical energy)*.


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9. Draw the following flow chart on the board to represent this energy transformation.

   electrical energy → radiant energy

10. Ask if anyone can state the **law of conservation of energy** *(energy cannot be created or destroyed, but it can be transferred or transformed)*. This means that the amount of energy in the universe remains the same! However, energy can be transferred to different objects or transformed into other forms.

    Option: Burn a match to demonstrate that chemical energy can be changed into light and heat, ask students to rub their hands together to show how motion energy can be transformed into heat, or stretch and release rubber band to show transformation from potential to kinetic.

11. Have students add this law to their concept map.

12. Now tell students that incandescent light bulbs are only about 10% energy efficient. This means that only 10% of the electrical energy put into the light bulb is converted into light.

    Option: Share the following equation with the students.

$$\text{efficiency (\%)} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$$

13. In Think-Pair-Share format, ask students: If energy cannot be created or destroyed, then what is happening to the rest of the energy that goes into an incandescent light bulb? *(It is converted into another form—thermal energy. Around 90% of energy supplied to an incandescent light bulb is converted into heat. This is often referred to as "lost" energy because it is not in a form that is useful for its purpose of providing light. A CFL light bulb, on the other hand, is about 25% efficient.)*[2]

14. Add this to your energy flow chart started on the board:

    electrical energy → radiant energy and thermal energy

15. Share with students that as energy is transferred from one object to another, the amount of useful energy usually decreases. This is because some energy (often heat) is usually given off to the surrounding environment. Because this energy is not available to perform work, it is often referred to as "lost" energy even though it still exists.[3]

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16. Now tell the class that they are going to break into groups of 4 and use their energy concept map to analyze the energy transformations that occur in different types of technology.
17. Break the class into small groups of 3-4 students and hand each group 1 set of *Energy Cards*. Give students about 15 minutes to discuss and complete the handout *Analyzing Energy Technology*.
18. When time is up or the groups are finished, review student work on the handout *Analyzing Energy Technology*. Possible answers for the energy flow diagrams include:

    Photovoltaic Cells: radiant energy → motion energy → electrical energy + thermal energy

    Internal Combustion Engine: chemical energy → thermal energy → motion energy + thermal energy

    Power Plant (thermal): chemical energy or nuclear energy → heat energy → motion energy → electrical energy

    Power Plant (wind, water): motion energy → electrical energy

    Fuel Cells: chemical energy → electrical energy
19. Reflect on the activity with the questions below.

Discussion Questions

1. How is energy relevant to your daily life?
2. For human energy needs, what forms of energy seem most useful? Least useful?
3. Why do you think thermal energy, or heat, is often referred to as "lost energy?" How could this phrase promote misunderstandings of the law of conservation of energy?
4. How is energy technology limited by natural laws?
5. If the total amount of energy in the world never changes (meaning that you can't add or remove energy from the planet), what do people really mean when they talk about "saving energy" by driving less or turning off lights?
6. What might be some of the impacts of human energy use? What are some unintended consequences of the technology that we have created to harness energy?


SGT. STEPHEN DECATUR, U.S. ARMY

Art and History Extension

Expand upon the law of conservation of energy by introducing students to the idea of perpetual motion machines and Rube Goldberg machines. (Rube Goldberg was a cartoonist and author. His cartoons depicted silly, complex machines that took many steps to perform a simple task.) You could begin by showing students one of the following videos and discussing how energy is wasted at various stages due to things like friction. Then have students research the age-old idea of the perpetual motion machine. As a final product, student groups can draw a fictional machine that will transfer and transform energy in order to accomplish a simple task—just as Rube Goldberg did with his comics.

- **Video:** *Honda Commercial with Rube Goldberg*
  http://www.teachertube.com/viewVideo.php?video_id=15955
  This 2-minute video shows a Rube Goldberg-type machine that has been made out of Honda car parts.
- **Video:** *OK Go—This Too Shall Pass*
  http://www.youtube.com/watch?v=-dJv7arn2IY
  The Los Angeles band OK Go performs their song *This Too Shall Pass* in the midst of a large Rube Goldberg contraption.
- **Website:** *Rube Goldberg*
  http://www.rubegoldberg.com/about
  This website provides a biography of Rube Goldberg and information about several Rube Goldberg competitions.

Service Learning Idea

Have students use what they have learned about energy to create energy books for primary school students. Then buddy up with a primary class and have students present and read their books to the children.

Additional Resources

- **Website:** *U.S. Energy Information Administration [EIA]*
  http://www.eia.gov
  The U.S. Energy Information Administration website is a wealth of information for students and teachers. From the homepage, you can click on a tab called *Learn About Energy* for explanations about energy concepts as well as lessons for teachers.
- **Ted Talk:** *Bill Gates on Energy: Innovating to Zero!*
  http://www.ted.com/talks/bill_gates.html
  The founder of Microsoft talks about energy and climate and the impacts of climate change for people around the world. He also discusses new nuclear energy technology.

Just Add Energy!

All of the objects or activities below require energy in some form.
What are some different ways you can categorize these uses of energy?

HOT WATER PHONE CHARGER CEMENT LIGHTING

PAPER PRODUCTION HEAT PUMPING WATER THINKING

RUNNING COOLING/FREEZING FOOD REFINING OIL

STADIUM LIGHTING AIR CONDITIONING DISHWASHER

CLOTHES DRYER PRINTER PLANE FARMING EQUIPMENT

CAR ROASTING MARSHMALLOWS COMPUTER TV

AUTOMATIC PENCIL SHARPENER TRUCK BIKING

MICROWAVE SEWING MACHINE MINING FOR COAL

WALKING EXTRACTING OIL EATING FOOD PLAYING MUSIC

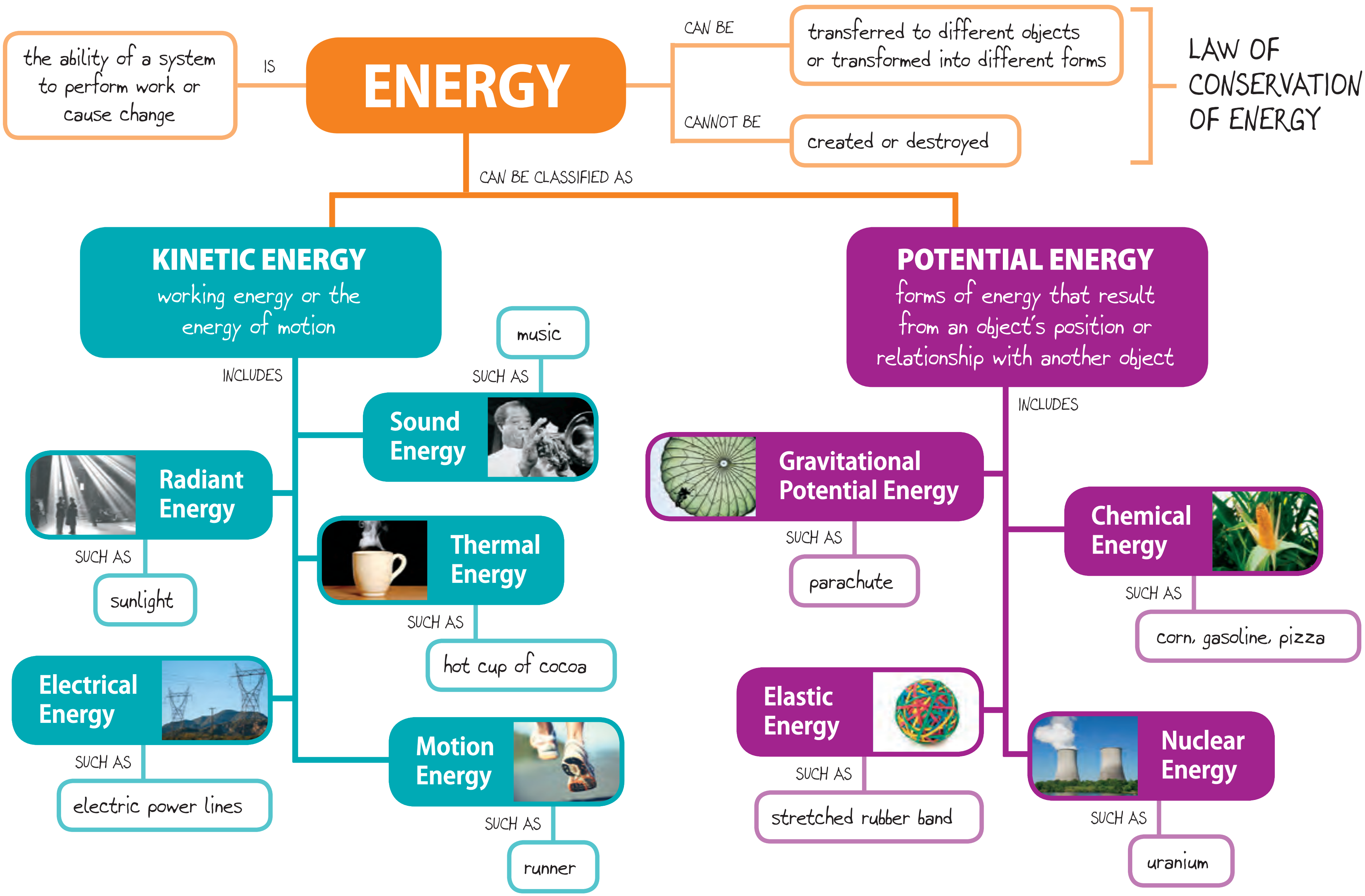
MANUFACTURING FAN LAWN MOWER SLEEPING

PACKAGING GROWING FOOD TRANSPORTING GOODS TO STORES

MANUAL PENCIL SHARPENER RECYCLING PAPER FERTILIZER

HAIR DRYER DVD PLAYER STOVE

Example: Energy Concept Map



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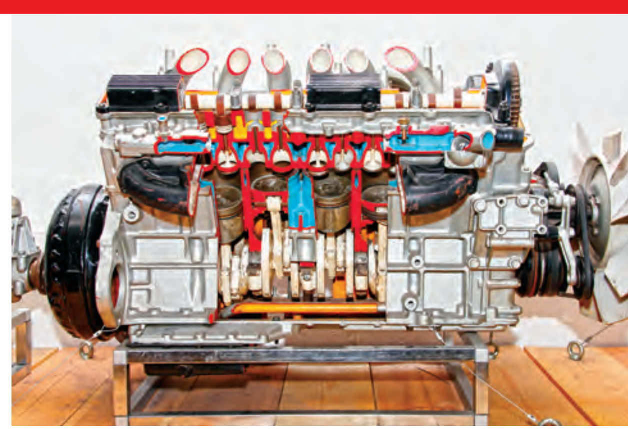
PHOTOVOLTAIC CELLS


JODIE VAN DE WETERING

Many people are installing solar panels on homes and buildings. Solar panels are made of photovoltaic (PV) cells that are designed to capture photons of sunlight and transform this energy into electricity. PV cells are made of two layers with different charges in order to generate an electrical field in the center of the cell. Sunlight hits electrons in top layers of the PV cells and causes them to move around. Some of these electrons reach the electric field and are pushed toward metal conductor strips on the bottom of the cell. These strips connect to a wire that conducts this electrical energy toward the house or building. Electricity also flows back in the opposite direction from the building toward the PV cells in order to create a circuit necessary for the transfer of electricity.[4] Solar panels are usually about 10-20% efficient.[5] This means that only 10-20% of the sunlight that reaches solar panels is converted into electricity. There are many reasons for this inefficiency. Not all wavelengths of sunlight are absorbed by PV cells and some light is reflected away from the panels. Also, some of this light is converted into heat rather than producing electricity.[6]

INTERNAL COMBUSTION ENGINE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Unless you drive an electric car, an internal combustion engine fueled by some sort of chemical energy (usually gasoline) lies just under the hood of your car. This engine converts chemical energy into heat energy in order to move the parts of the engine. The engine's motion energy is then transferred to the car's wheels to move your entire car.[7] Not all of the chemical energy from gasoline is converted into motion energy, however. In fact, only about 14-26% of the fuel's energy is used to move your car.[8] A tremendous amount is released as heat and the rest helps power the car's accessories, such as heating, air conditioning, and windshield wipers. The way you drive impacts your car's efficiency, too. The faster you drive and the more you idle, the less gasoline is converted into kinetic energy!

POWER PLANT


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Power plants generate electricity. They have 3 main parts that help them do this: a turbine, shaft, and generator. A turbine is a machine made of blades that turns when pushed by something with kinetic energy (such as steam, wind, or water). The turbine is connected to a shaft that turns inside the generator whenever the turbine moves. There are copper coils and magnets inside the generator and when the shaft turns, kinetic energy is converted into electricity. This electricity is sent from the power plant to the electrical grid and eventually makes its way to your home. Remember that energy cannot be created out of thin air! Therefore, all power plants must have some sort of energy input. Thermal power plants burn chemical energy or use nuclear fission to produce steam or hot gases that move the turbine.[9] The efficiency of thermal power plants ranges from 29-55%. In other power plants, moving water or wind turns the turbine. Wind power plants are about 45-50% efficient while hydropower plants can be 90% efficient![10]

FUEL CELLS


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Depending on their size, fuel cells can be used as a power source for cell phones, cars, or even entire power plants. They can be a back-up supply of power for people without access to the electrical grid or during disasters. For instance, during Hurricane Sandy fuel cells were used to provide power for cell phone towers in order to help communication lines stay open.[11] Fuel cells function like batteries in that they use chemical energy to generate electricity. Chemical reactions take place inside the cells and produce electrons that flow around an external electric circuit to provide power for the machines they are connected to. Fuel cells use hydrogen as fuel and oxygen from the air to produce electricity, water, and heat. No pollution is emitted during this process and no oil is needed to fuel the car.[12] The energy efficiency of fuel cells for cars ranges from 40-60%.[13]

Name Date Class

Analyzing Energy Technology, page 1

Directions: Draw an energy flow diagram to represent the energy transformations that take place for each of the following pieces of technology. Then answer the questions below.

Photovoltaic Cells	Internal Combustion Engine
Power Plant	**Fuel Cells**

1. In general, what is the purpose of the above technology? In general, what are some trade-offs of the above technology?

2. Which technologies listed above require an input of potential energy?

Name Date Class

Analyzing Energy Technology, page 2

3. Which technologies listed above require an input of kinetic energy?

4. Which of the above technology can be easily transported from one place to another?

5. Which seem to be dependent upon location? Why?

6. In general, which forms of energy were produced that were considered “waste” energy?

7. How do the machines above demonstrate the law of conservation of energy?

Lesson 2

Power to the People!

Students identify an activity they do which requires electricity. Working backwards from this activity, they sketch the path electricity travels as far back as they can. Small groups then read about a nonrenewable or renewable energy source used to generate electricity and identify its pros and cons. Small groups share their research with the class and together come up with a sustainable fuel mix for their region.

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Objectives

Students will:

- sketch the path of electricity from one's home or school to a power plant
- identify the pros and cons of a primary energy source
- use class research to recommend a sustainable fuel mix for your region

Inquiry/Critical Thinking Questions

- How is electricity generated?
- What are the pros and cons of different energy sources used to generate electricity?
- What are sustainable fuel mixes for our region?

Time Required

One 60-minute class

Key Concepts

- **electric grid**—A system that distributes electricity from power plants to locations that use electricity; it includes power lines, power generators, transformers, and all of the homes and businesses that use electricity.
- **electricity**—A form of energy associated with the movement of charged particles; generally produced as a secondary form of energy by converting other forms of energy, such as coal or wind, into electricity.
- **fuel mix**—The amount and type of energy sources used to supply the energy demands of a particular region.
- **nonrenewable resource**—A limited resource, such as coal, natural gas, or oil that cannot be replaced in a short amount of time.
- **primary energy source**—A source of energy that has not yet been converted by humans for any other use. For example, when coal is burned to produce electricity, coal represents the primary energy source and electricity represents the secondary energy source, or energy carrier.
- **renewable resource**—A resource, such as biomass, sunlight, wind, or water, that can be replaced quickly and naturally.
- **secondary energy source, or energy carrier**—A source of energy that results when humans transform or transfer energy from another source. For example, when coal is burned to produce electricity, coal represents the primary energy source and electricity represents the secondary energy source, or energy carrier.
- **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

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Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.2 Human use of energy is subject to limits and constraints.

4.4 Humans transport energy from place to place.

4.5 Humans generate electricity in multiple ways.

4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.

Materials/Preparation

Download the video *Energy 101: Electricity Generation* from the energy Now! website: http://www.energynow.com/video/2011/09/27/energy-101-electricity-generation

Internet access to show state fuel mix

Handout: *Power to the People!*, 1 per student

Handout: *Energy Source Fact Sheets*, 9 different topics for 9 groups of students, 1 per student[1]

Optional: Internet access for further research, 1 computer per small group

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Activity

Introduction[*]

1. Begin the class by asking students to identify one activity they do that requires electricity *(such as using a light to study or charging a cell phone in an electrical outlet).*
2. Working backwards from this activity, on a blank piece of paper have each student sketch the path that electricity takes to get to their homes or schools to power the activity they identified. Assure students that this initial sketch is a brainstorm and to sketch as far back as they can.
3. As students draw, circulate around the room to get a sense of student ideas and possible misconceptions about electricity.
4. In Think-Pair-Share format, have students explain their sketches to one another and discuss which parts of this path were most difficult to draw or imagine.
5. Prep students to view a short animation on electricity generation. Encourage them to look for clarification on the concepts of electricity generation that are particularly confusing to them or they were unable to draw.
6. Show students the video *Energy 101: Electricity Generation.*
7. Give students 2-3 minutes to review and revise their initial sketches as needed.
8. In Think-Pair-Share format, have students describe if and how their ideas about electricity changed from the beginning of this activity.

* Adapted with permission from *Power Source* by Steven Semken, Arizona State University.

Steps

1. Show your class the **fuel mix** used to generate electricity in your state or region using one of the following resources:
   - **Graphic:** *Visualizing the U.S. Electric Grid*
     http://www.npr.org/templates/story/story.php?storyId=110997398
     This graphic created by National Public Radio is an interactive map of the United States that shows major transmission lines, the percentages of different sources of power used in different states, solar and wind power transmission lines, and the location of different power plants.
   - **Website:** *Clean Energy*
     http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html
     This *U.S. Environmental Protection Agency* website allows you to enter your zip code to learn about the fuel mix and the resulting emissions for your region.
   - **Website:** *U.S. Energy Information Administration*
     http://www.eia.gov/state/
     Click on a particular state to access regional energy profiles that include information about the fuel mix used to generate electricity.

KIMBERLY CORRIGAN

2. Explain to the class that today small groups or partners (depending on your class size) will research and evaluate the different primary energy sources used to generate electricity (a secondary energy source). Each group will research 1 primary energy source and then share its pros and cons with the class. The class will then use this information to determine whether the fuel mix in your region could be more sustainable. As a class define the word **sustainable**.

   Option: You may want to define and discuss the difference between **primary** and **secondary energy sources**. *(Primary energy sources include coal, natural gas, and wind power. Primary energy sources can be renewable or nonrenewable. On the other hand, electricity is a secondary source of energy. Secondary energy sources, or energy carriers, are sources of energy that humans have generated by the conversion or transference of another source of energy. For example, electricity and hydrogen can both be produced by fossil fuels. Secondary energy sources are also called energy carriers because they move energy from one location to another in a useable form.)*

3. Divide the class into 9 equal-sized groups, and assign each group 1 of the following sources of energy: biomass, coal, geothermal, hydropower, natural gas, petroleum (oil), solar, uranium, or wind. Give groups the appropriate *Energy Source Fact Sheets.*

4. Provide groups with 15 minutes to read the fact sheets and complete the handout *Power to the People!*

   Option: Give students more time to further research their energy source. The following are some additional resources for research:

   - **Fact Sheets:** *National Energy Education Development Project: Energy Infobooks* http://www.need.org/Energy-Infobooks Click on the titles in the Secondary section for fact sheets on each energy source. These chapters can also be printed out.
   - **Website:** *Energy Explained* http://www.eia.gov/energyexplained/index.cfm This U.S. Energy Information Administration website provides information about nonrenewable and renewable sources of energy. There is also a version geared toward younger students, *Energy Kids* (http://www.eia.gov/kids/index.cfm).

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- **Website:** *National Geographic: Environment*
  http://environment.nationalgeographic.com/environment/global-warming/wind-power-interactive/
  This website has an interactive called Wind Energy: Harnessing the Air in Motion where students can learn about the different parts of a wind turbine and how these parts help generate electricity. Students can also manipulate different physical features of the turbine to see how this impacts electricity generation.

5. Bring the class back together.
6. Give each group about 2 minutes to clearly state their group's position, explain their reasoning and the trade-offs of their position, and suggest ways to make the use of their energy source more sustainable.
7. Allow other groups to ask questions after each group presents.
8. After all groups have presented, remind students of your region's particular fuel mix.
9. In Think-Pair-Share format, have students use what they just learned about different energy sources to consider whether they would alter this fuel mix.
10. Continue your class discussion with the discussion questions below.

Discussion Questions

1. When you take into account the pros and cons of each energy source, which one(s) seem to be the most sustainable? Why?
2. What could be some advantages and disadvantages of using many different energy sources (this is called fuel diversity) to produce electricity?
3. Did you notice any patterns or similarities in the pros and cons of the different energy sources?
4. Consider the renewable energy sources discussed today. Can you make any conclusions about the relationship between renewability and sustainability?
5. How has your thinking about electricity changed after this lesson? How might this impact your behavior?
6. If you were hired to promote awareness about electricity generation, what is the single most important concept you would focus on?
7. Besides choosing sustainable energy sources to produce electricity, what are some other ways that individuals and communities can lessen some of the negative impacts of generating electricity?


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Communications Extension

Hold a classroom debate in which small groups argue an energy issue. Possible debate topics include:

- Our nation should significantly increase the amount of electricity generated by nuclear power plants.
- Our nation should stop mining for and using coal as an energy source.
- Our region should significantly increase the amount of electricity generated by renewable energy sources.

Resources on classroom debates can be found online at:

- *International Debate Education Association*
  http://idebate.org/
- *Public Debate Program*
  http://highschooldebate.org/

Service Learning Idea

Give students more time to research the fuel mix in your region and consider the environmental impacts from resource extraction, resulting emissions, and renewability of each fuel relied upon within the region. Students can educate their community about ways the region could adopt a more sustainable fuel mix.

Additional Resource

- **Video:** *Smart Grid*
  http://video.pbs.org/video/1801235533/
  This 9-minute video created by NOVA Science Now analyzes the current U.S. electric grid and the benefits of adopting a smart grid for the future to increase energy efficiency.

Name Date Class

Power to the People!, page 1

Group Members: ______________________________

Energy Source: ______________________________

Part I. Summary

Directions: Draw a sketch to represent how this energy source can be used to generate electricity.

Part II. Analysis

Directions: Use your research to identify the main pros and cons of your primary energy source.

Pros	Cons

Name Date Class

Power to the People!, page 2

Part III. Recommendations

Directions: Read the questions below and then discuss the answers with your group. Once your group has reached a consensus, record your answers below.

Position Statement

In 1 sentence, clearly state whether or not your group believes this type of energy source should be used in your region to generate electricity. If you believe it should be used, but only with specific limitations, then make that clear.

Reasoning

Explain the 3 main reasons for your position.

Trade-offs

Explain at least 2 trade-offs, or compromises, that would likely occur because of your position.

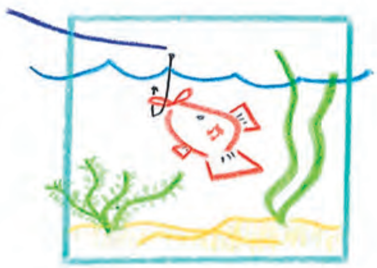
Improvements

Describe or sketch at least 2 ways that the use of this energy source could be made more sustainable than it is now.

Energy Source: Biomass

BIOMASS is living or recently living organic matter from plants and animals. Biomass can be used as a fuel source because plants and other photosynthesizing organisms (such as algae) convert the sun's energy into stored chemical energy. When animals eat these photosynthesizing organisms, this stored energy is passed on up the food chain.

YESTERDAY

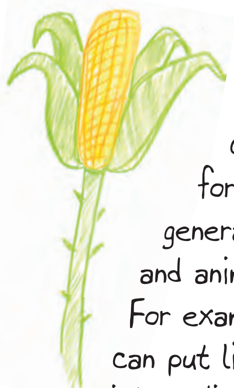


TODAY

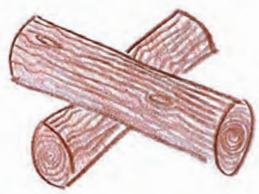
Biomass is considered a **RENEWABLE** energy source because we can quickly regrow plants.

How do we harness the energy stored in biomass? We **BURN** it!

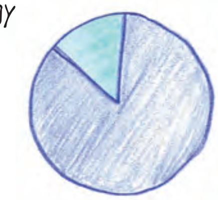
The heat produced is used to boil water, generating steam that will turn a turbine and produce electricity. We can also burn **METHANE** emitted when biomass decomposes to produce electricity.



Wood and crops (such as corn) are the most common forms of biomass used to generate electricity. Garbage and animal manure can also be used. For example, farmers can put livestock waste into a digester to generate methane.



There are 76 waste-to-energy plants in the United States. While currently more expensive to run than other electrical plants, they also reduce the amount of garbage we add to landfills. We do have to be careful about burning items like batteries and light bulbs that can release toxins into the environment.



85%
OF HOUSEHOLD TRASH IS ABLE TO BURN

Over millions of years, the stored chemical energy in biomass is condensed and transformed into fossil fuels. So the **ENERGY DENSITY** (the amount of energy stored in a given volume) of fossil fuels is very high, much higher than biomass.

What about **CO_2** emissions?

Burning biomass will release CO_2 into our atmosphere, impacting our climate. If crops are replanted, the new crops could **OFFSET** these emissions by absorbing CO_2 as they grow. The CO_2 released from fossil fuels may have a greater impact on our climate because fossil fuels release CO_2 that has been absent from the atmosphere for millions of years.

Each type of biomass used to generate electricity has its own advantages and disadvantages. For example, using crops to generate electricity on a large scale may require large amounts of energy, fertilizers, and land. Depending on how and where crops are grown, this could reduce the land available to grow food, impacting food security and global food prices.

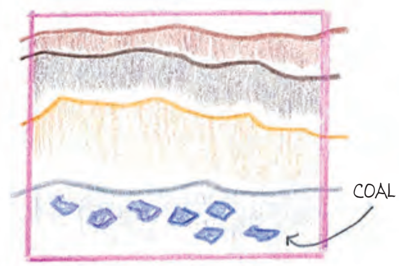
Energy Source: Coal

FOSSIL FUELS are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure, which transforms them into fossil fuels in the form of oil, natural gas, and **COAL**.

How do we get it out of the ground?
MINING
Coal can be found right on Earth's surface or hundreds of feet below ground.

Surface mining techniques include **STRIP MINING** (stripping the plants, soil, and rock from the surface to get at the coal) and **MOUNTAIN TOP REMOVAL** (removing entire mountain tops to get at the coal).


MILLIONS OF YEARS AGO



TODAY

Coal is generally one of the most abundant fuel sources in the United States. The primary use of coal is for electricity.

Coal is considered a **NONRENEWABLE** energy source because it takes so long to form. The amount of coal in the world is **FINITE**.

There are 4 different kinds of coal—each contains a different amount of carbon. Each kind also contains a different amount of energy.

Coal is found all over the world, but the United States, Russia, and China possess the largest reserves. Coal is mined in 25 states, the most significant of which are Wyoming, West Virginia, Kentucky, Pennsylvania, and Texas.

Mining releases a great deal of ash and dust, air pollutants, into the local environment and this pollution can result in acid rain. Also, using coal for electricity production releases more CO_2 than any other energy source.

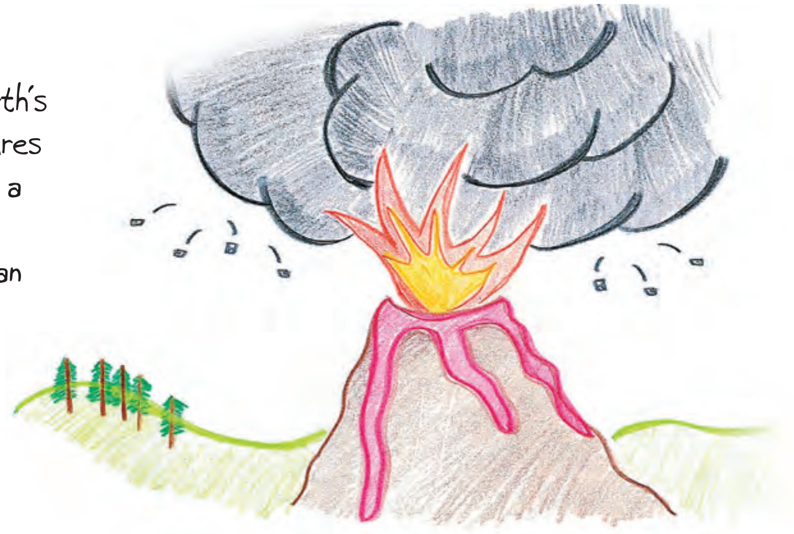
UNDERGROUND MINING involves a lot of digging as well as the construction of mine shafts and elevators to bring miners below ground to extract the coal. Underground mine workers are vulnerable to health hazards like respiratory illnesses and lung disease.

Transporting coal to power plants requires that energy be used to fuel coal trains, trucks, and barges—especially since coal, as a solid, cannot be moved along a pipeline.

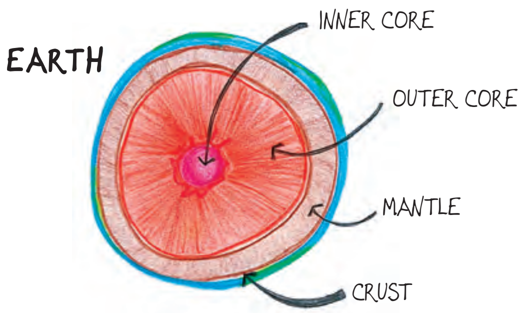
What does it mean when people use the phrase **CLEAN COAL**? "Clean coal" refers to technologies (sometimes called scrubbers or cleaners) developed to capture and store air pollutants generated from the combustion of coal before they enter the atmosphere.

Energy Source: Geothermal

The constant decay of radioactive particles in Earth's molten iron core produces extremely hot temperatures (hotter than the sun's surface). This slow decay is a process occurring in all rocks. The heat generated is referred to as **GEOTHERMAL** energy and can be used to produce electricity.



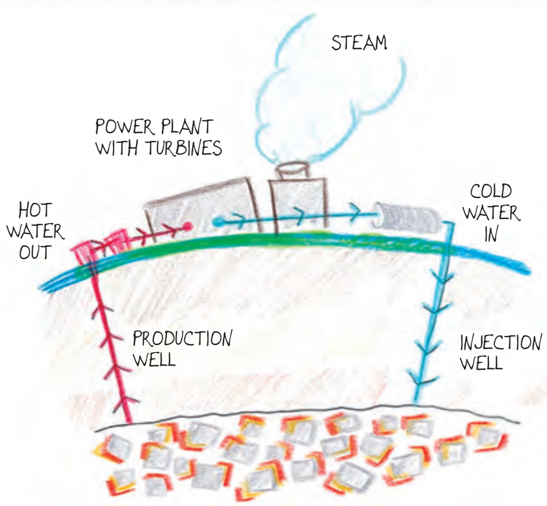
Geothermal energy is considered a **RENEWABLE** energy source because heat is being generated continuously in Earth's core.



While geothermal **RESERVOIRS** may be hard to reach deep beneath Earth's surface, **VOLCANOES**, **HOT SPRINGS**, and **GEYSERS** are a good sign of geothermic activity below. However, drilling is required to confirm hot temperatures below, and not all reservoirs will have visible clues at the surface.

Building a geothermal power plant can be very expensive. In addition, drilling for geothermal reservoirs may affect land stability in the area. Geothermal energy is not dependent upon weather, unlike wind and solar. Geothermal power plants also emit less than 1% of the CO_2 emissions that fossil fuel power plants emit.

Once a reservoir is found, pipelines are drilled 1 to 2 miles below the surface to reach steam or water as hot as 700°F. Some geothermal plants take steam directly from Earth to power a generator; other plants take hot water and convert it to steam to power the generator. Either method will take the steam or water used to generate electricity and inject it back in the ground to reheat.

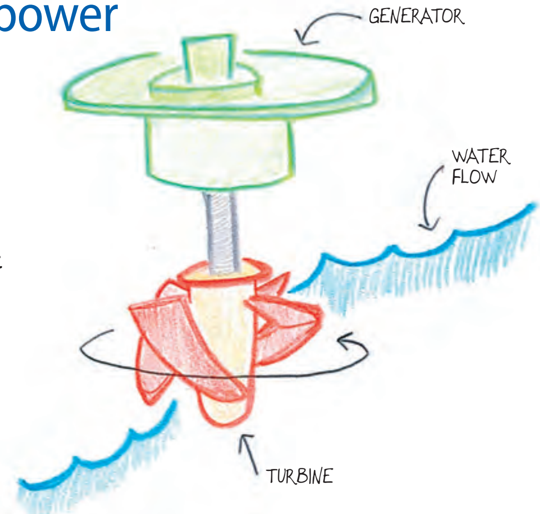


GEOTHERMAL RESERVOIR

Currently, the United States, the Philippines, and Iceland have the most geothermal power plants. California has 36 geothermal power plants, the most of any state.

Geothermal energy may rely on water from Earth's core that contains chemicals harmful in high doses such as **HYDROGEN SULFIDE** which smells like rotten eggs. Geothermal power plants may be designed to capture these chemicals before they are released into the atmosphere.

Energy Source: Hydropower



HYDROPOWER refers to the **KINETIC ENERGY** of moving water. The amount of kinetic energy will depend on flow or fall.

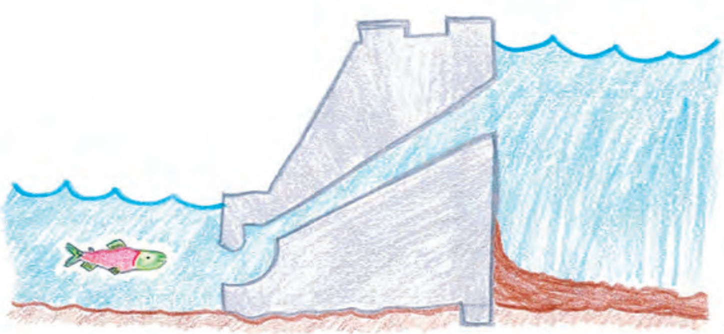
Hydropower is considered a **RENEWABLE** energy source because water is continuously moving as a result of Earth's water cycle.

Water is denser than air. Because of this, more energy may be captured from a water turbine than a wind turbine. However, the density also requires a sturdier structure to capture the energy. As a result, hydropower projects are often more expensive.

About **11%** of electricity in the U.S. comes from hydropower.

One common way to harness the energy of moving water is to build a **HYDROELECTRIC DAM** (not all dams are constructed for energy use) along a river. Releasing water from a **RESERVOIR** (the body of water held behind a dam) can push water fast enough against a turbine to spin its blades, generating electricity. Rivers already moving fast enough to turn the blades of a turbine may not require a dam. **RUN-OF-THE-RIVER** or **DIVERSION** designs can harness the energy of these fast moving rivers.

Large dams can have significant **SOCIAL** and **ENVIRONMENTAL** impacts. When constructed, dams will often flood dry land near the reservoir, as water backs up behind the dam. Many living in the area are forced to move.



We can also capture the energy of **TIDES** and **WAVES** using other technologies, but all technologies funnel water along a path that is pushed against a turbine.

Hydropower has been used for thousands of years. Today, in the United States, hydropower is mostly used to generate electricity.

Changing the path of a river can have harmful effects on other organisms. Dams prevent the migration of fish, such as **SALMON**. Fish ladders have been developed at many dams to help the fish swim past, but many cannot navigate their way through the structure. Also, **SEDIMENTS** (soil, sand, and leaves) can build up in reservoirs. These sediments reduce water quality for organisms that live in the water and can choke out sunlight.

There have been community efforts to remove dams built long ago and to restore river and surrounding ecosystems to their natural state. For instance, the Elwha Dam in Washington State was removed in 2012 to help restore local fisheries.

Energy Source: Natural Gas

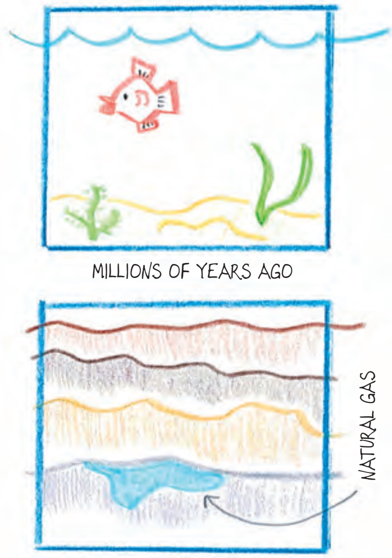
FOSSIL FUELS are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure, which transforms them into fossil fuels in the form of coal, petroleum, and **NATURAL GAS**.

Geologists search for natural gas by studying underground rock formations and setting off explosions to record sound waves.

How do we get it out of the ground?

DRILLING and **FRACTURING**

We use a variety of techniques to extract natural gas from the ground. One is called hydraulic fracturing (or fracking). To release natural gas trapped in rock, a high pressure mixture of water, sand, and toxic chemicals is pumped into the rock to break it up.

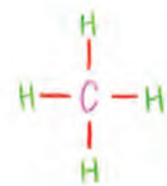


Natural gas reserves are often found in wilderness areas. Extraction can involve destruction of the natural environment and harm to local plants and animals. Chemicals used in fracking may also contaminate local water sources and drilling has been known to leave the ground unstable.

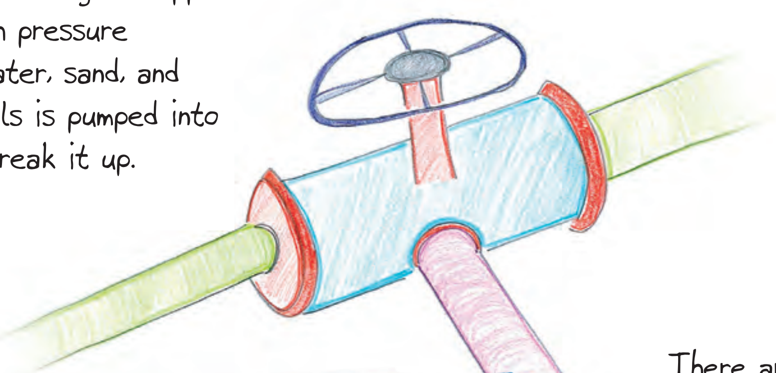
Natural gas is considered a **NONRENEWABLE** energy source because it takes so long to form. The amount of natural gas in the world is **FINITE**.

Texas, Wyoming, Louisiana, and Oklahoma are top natural gas producing states. The United States also imports natural gas from Canada. Russia possesses the largest natural gas reserves in the world.

Natural gas is a colorless, odorless hydrocarbon that is mostly composed of methane (a molecule made of 1 carbon atom and 4 hydrogen atoms).



METHANE has a greenhouse effect 72 times greater than CO_2 and may be released during extraction, transport, and distribution of natural gas. A growing dependence on natural gas will lead to a rise in methane emissions.



Natural gas may leak during production and distribution. The gas is highly flammable, so an odor is added to make natural gas smell like rotten eggs so that serious leaks can be immediately detected.

How do we transport it?

PIPELINES

There are more than 300,000 miles of natural gas pipelines in the United States. Pipelines move natural gas to plants for processing and storage. Gas is often saved until winter when energy needs are high. Then natural gas is transferred to power plants and burned to create electricity.

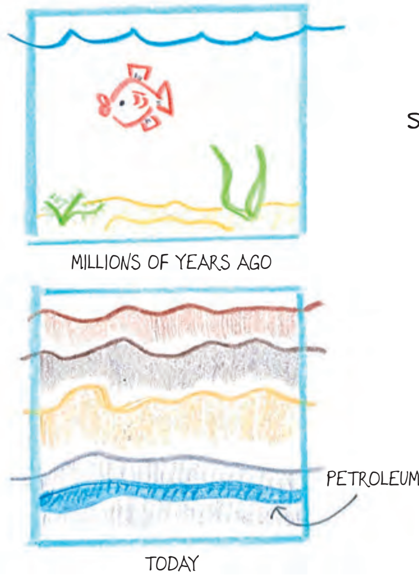
Energy Source: Petroleum (oil)

FOSSIL FUELS are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure, which transforms them into fossil fuels in the form of coal, natural gas, and **PETROLEUM**.

How do we access it?

DRILLING

We use a drilling rig and derrick to pump the oil up from thousands of feet below ground. We also drill into the ocean floor to access oil reserves. **OFFSHORE** drilling is more expensive. Currently over 1/3 of our oil supply is extracted from offshore wells. Typically, 1 oil well produces about 10 barrels of crude oil a day. Though the longer we drill at one well, the less oil we extract over time.



Petroleum has been burned to produce light for thousands of years in places like China and Egypt.

How do we process it?

REFINEMENT

Once pumped from the ground, oil is sent to a refinery where it can be separated out by weight and boiling point into gasoline, diesel, heating oil, jet fuel etc. Contaminates such as sulfur are also removed in the refining process. Once refined, oil can be burned at a power plant to produce electricity.

Petroleum is considered a **NONRENEWABLE** energy source because it takes so long to form. The amount of oil in the world is **FINITE**.

To find petroleum reserves, geologists study underground rock formations to predict where oil is likely to be found. In 2010, only 61% of exploratory wells found oil.

Petroleum has been found in 31 states, but mostly in Alaska, California, North Dakota, Oklahoma, and Texas. We import about 1/2 the petroleum we use, mainly from Canada and Mexico. The Middle East possesses the world's largest petroleum reserves.

Petroleum products include gasoline, fertilizers, pesticides, plastics, and medicines.

How do we transport it?

PIPELINES, BARGES, and TRUCKS, oh my!

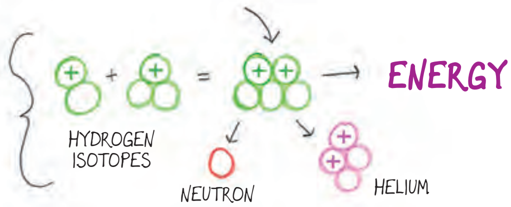
We have to transport oil all over the United States. Since WWII, oil has replaced coal as our primary energy resource. Petroleum is popular because it is more energy dense than coal or natural gas. However, only 1% of our petroleum consumption is used to produce electricity, while 71% is used to power our transportation sector.

The processing, combustion, and disposal of petroleum often creates air and water pollution. The emission of CO_2, a greenhouse gas, is a big health and environmental cost of petroleum. Oil spills are frequent and can harm wildlife, pollute water, and release noxious fumes.

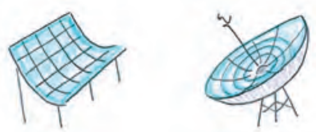
Energy Source: Solar

The sun produces **RADIANT** energy as gasses in its core undergo **NUCLEAR FUSION**. This energy travels through space and reaches Earth as it orbits the sun. Solar is considered a **RENEWABLE** energy source because the sun's energy production is constant.

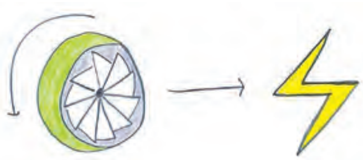
This energy can be used to generate electricity in **2** ways.



We can convert the sun's energy into electricity using **SOLAR THERMAL SYSTEMS**. Solar thermal systems use a variety of methods (from mirrors to dishes)

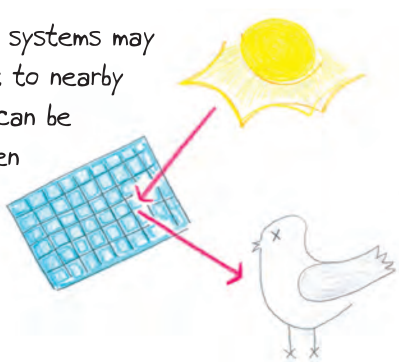


that concentrate the sun's rays toward one spot to heat water and turn it into steam. The steam is then used to turn a turbine, which generates electricity through motion.



This is similar to the process used by power plants that burn fossil fuels to generate electricity. However, no carbon dioxide is emitted as a result of solar thermal systems.

Solar thermal systems may pose a threat to nearby wildlife that can be caught between the mirrors and their trajectory.



We can convert the sun's energy into electricity using **PHOTOVOLTAIC (PV) CELLS**.

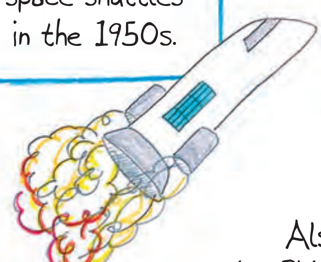
PV cells are made of semiconductors such as pure silicon. The cells are grouped together in panels.

> Silicon can be extracted from sand. Silicon will not act as a semi-conductor forever. Eventually the silicon will need to be replaced.

You can find PV cells on rooftop solar panels, as well as in watches, calculators, and space shuttles.

PV cells are not as efficient as fossil fuels with current technology. PV cells convert 11-27% of the sun's radiant energy into electrical energy. Burning fossil fuels converts 35% of their chemical energy into electrical energy.

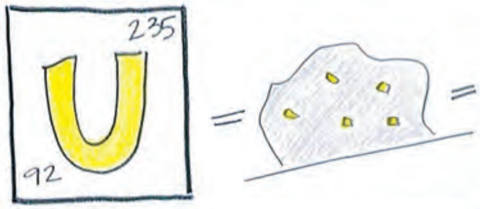
> PV cells were first used on space shuttles in the 1950s.



Also, toxic chemicals are often used to make PV cells. These toxic chemicals must be handled and disposed of properly in order to keep the environment and the people in the local community safe.

> The availability of solar power depends upon weather, time of day, and location. Catching all that sunshine requires a great deal of surface area, since the sun's energy is not concentrated.

Energy Source: Uranium

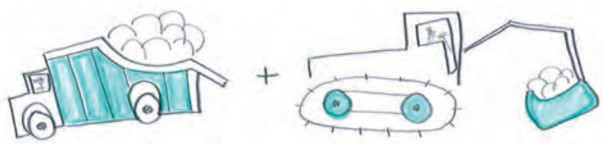


3rd most common energy source for electricity in the United States

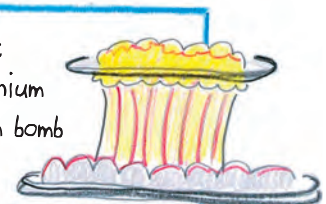
Uranium is a **NONRENEWABLE** metal found in rocks all over the world. Uranium is the most common element used by power plants that generate energy by **NUCLEAR FISSION** because the uranium atom splits more easily than other atoms. Uranium is more common than silver, but most uranium has to be enriched into a form that can be used by nuclear power plants (U-235).

How do we get Uranium?

We **MINE** for it!



The use of uranium was first developed in the 1930s. Uranium was used to create the atom bomb dropped during WWII.



We mine for uranium using a variety of techniques including solution, open pit, underground, and heap leaching mining. We mine for uranium all over the world.

The mining process itself uses a lot of energy (fuel and electricity). For example, solution mining involves dissolving the uranium ore in a solution and then pumping it to the surface.

What's next? We **PROCESS** it!

1. We crush uranium ore up and treat it with chemicals to separate the uranium from the rock.

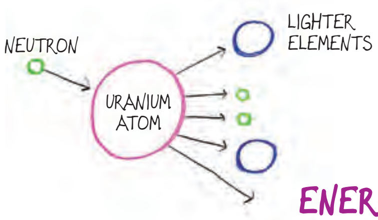
2. We collect and dry the remaining substance, called yellowcake, and convert it into a gas.

3. We enrich the uranium to make it more concentrated.

4. We then package the uranium into pellets the size of your fingertip. Each pellet contains a potential energy equal to 150 gallons of oil.

Now what? **FISSION!**

We transport the enriched uranium to a nuclear reactor facility where fission can occur. In fission, uranium atoms are split to release energy.



ENERGY!

HEAT RADIATION

This heat is used to boil water into steam. The steam is then used to power a turbine to generate electricity.

Nuclear reactors do not create air pollution, unlike power plants that burn fossil fuels for energy. They do create **RADIOACTIVE WASTE** that lasts tens of thousands of years.

What do we do with the waste?

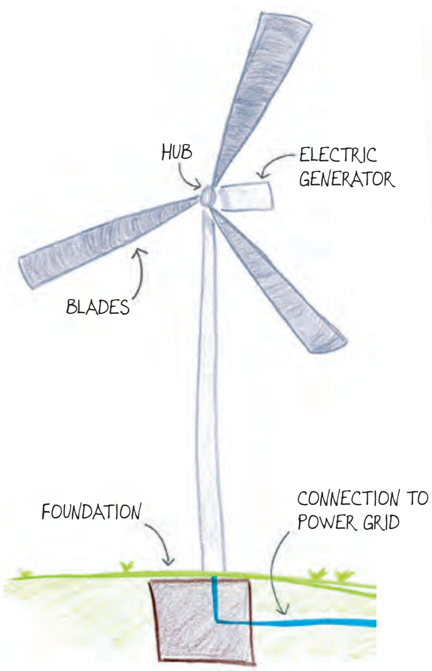
NOT SURE.

We keep uranium waste (spent fuel) in cool pools of water or bury it deep below the ground. But these are temporary fixes. We have not yet developed a permanent storage method. Uranium waste can release radiation back into the environment, where it poses a threat to ecosystems and human health. Radiation can cause birth defects, cancer, and death.

Energy Source: Wind

The uneven heating of Earth's surface produces **WIND** energy. Earth is warmed unevenly for a variety of reasons: the poles are farther from the sun than the equator and Earth's surfaces vary, some absorbing the sun's energy easily (dark sea), while other surfaces are more reflective (ice).

Wind has been used as an energy source for thousands of years to propel boats and pump water. Wind energy can also be converted into electricity with wind **TURBINES**. Wind turbines can be built on land or offshore, wherever wind is consistent. The wind causes the turbine's blades to spin. The blades are connected to a drive shaft, which turns an electric generator, converting **KINETIC ENERGY** into electricity.

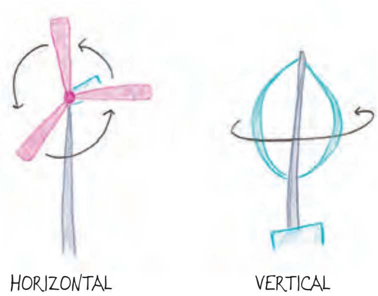


Some ranchers and farmers have installed wind turbines on their land to make a little extra money and save on their energy bills. With the added income from wind power, farmer and ranchers are better able to preserve their forest, grazing, or farmland and for continued agricultural use.

Wind is considered a **RENEWABLE** energy source because the relationship between Earth and the sun will constantly generate wind, though some places are better suited for wind energy production than others.

The best locations for **WIND FARMS** (where a group of wind turbines are built to produce electricity) are open areas without wind breaks. The biggest wind farm is in Texas, with over 400 wind turbines, generating enough electricity to power 220,000 homes each year. In 2012, 3% of U.S. electricity came from wind. Denmark relies on wind power for 19% of its electricity.

Wind turbines come in 2 forms: **VERTICAL** and **HORIZONTAL**. Horizontal is the more commonly used. Horizontal turbines may be as tall as a 20-story building with blades longer than a football field.



Converting wind energy into electricity creates little pollution and the fuel (wind) is free! Wind turbines, however, are often built from steel and other **MINERALS**, resources extracted from the ground through mining. Wind turbines may pose a threat to wildlife, including birds and bats.

Lesson 3

Lighten Up: A Personal Energy Audit

Students begin by considering the impacts of energy use on society, economy, and environment. Students then investigate their own energy use by performing a personal energy audit. In reflection, students identify ways they can conserve energy or use energy more efficiently in their daily lives.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Objectives

Students will:

- demonstrate their attitudes and beliefs about energy use and conservation
- identify and record appliances at home that require electricity
- calculate their personal consumption of electricity
- read an electric bill
- identify behaviors and technology that can help reduce personal electricity use

Inquiry/Critical Thinking Questions

- How do I use electricity on a daily basis?
- What can I do to reduce the amount of electricity I consume every day?
- How do I read an electric bill?

Time Required

One 60-minute class

Key Concepts

- **energy audit**—An inspection of a building in order to evaluate or improve energy use or safety.
- **energy conservation**—Behaviors and actions that save or use less energy, such as turning off the lights when you leave a room.
- **energy efficiency**—Completing a specific task with less energy input than usual, such as using an energy-efficient LED light bulb which uses less energy than other light bulbs to produce the same amount of light.
- **power**—The rate at which energy flows.
- **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

1.7 Many different units are used to quantify energy.

1.8 Power is a measure of energy transfer rate.

6.2 One way to manage energy resources is through conservation.

6.5 Social and technological innovation affects the amount of energy used by human society.

6.6 Behavior and design affect the amount of energy used by human society.

6.8 Amount of energy used can be calculated and monitored.

Materials/Preparation

Before class, give each student the handout *Personal Energy Audit* and discuss how to fill it out at home. The students need only complete the first two columns for Part I and answer the questions in Part II. The rest of the handout can be completed during class the next day.

> **Note:** Some students may not have access to an electric bill at home. If this is the case, students can use the following link to answer Part II of the handout based on average household energy use by U.S. state: **http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3** (click on second link, *Average monthly residential electricity consumption, prices, and bills by state*).

Post signs that say "Always/Yes" and "Never/No" on opposite sides of the room or in the hallway

Handout: *Personal Energy Audit,* 1 per student

HENRI BERGIUS

Activity

Introduction

1. Explain to the class that before they begin their personal energy calculations, they will participate in a short questionnaire.
2. Point out the signs posted on the opposite ends of the room or hallway. Explain that these signs represent the rating scale for the questionnaire. After you read a statement, students will move to a location that represents their answer. They can stand right under a sign or somewhere in between to represent "Sometimes/Maybe."
3. Read the following statements one at a time. After each question, you could ask a volunteer from each side to explain his or her answer.
   - I turn the lights off when I leave a room.[1]
   - Riding a bike instead of driving a car can reduce pollution.
   - Reducing the amount of energy I use will decrease the quality of my life. *(Not necessarily. For instance, carpooling or walking to school with friends could be more enjoyable or build relationships that driving alone might not.)*
   - Electricity production is the largest source of carbon dioxide (CO_2) emissions in the United States. *(This is true. Electricity generation is about 38% of the total carbon dioxide emissions in the U.S.)*[2]
   - The decisions I make about energy use can have a far-reaching impact. *(This could be true. For instance, carbon dioxide emissions from energy use have no borders and one may use an energy source that is imported from another country.)*
   - Energy efficiency and energy conservation have different meanings. *(This is true. Conservation generally refers to behaviors and actions that go without energy consumption while efficiency generally refers to using less energy to do the same job.)*
   - Power and energy are the same thing. *(This is false. Power is the rate at which energy flows.)*
   - I can encourage my peers to make better energy decisions.
4. Have students return to their seats.
5. Remind students that they are about to estimate their personal electricity use and ask the class, "Why should we even care about our electricity use?" Encourage the class to come up with at least 1 economic, environmental, and social reason. *(Answers will vary but may include: the cost of an electricity bill—in fact, the typical household spends more than $1,900 a year on energy bills[3]; that electricity production is the leading cause of CO_2 emissions in the United States; that the extraction of the fossil fuels used to generate most of the electricity in the United States can pollute the environment and harm human health.)*


KATE DAVISON, GREENPEACE SOUTHEAST ASIA

Steps

1. Have students get out the handout *Personal Energy Audit.* Students should have partially completed the handout at home.
2. In Think-Pair-Share format, ask students what surprised them most about the information they have collected so far for this activity.
3. Tell the class that today they will use the information they gathered at home and additional information provided in their handouts to calculate an estimate of the amount of energy they use.
4. Remind students that we measure things using specific units. In Think-Pair-Share format, ask students to name some units that they might use to measure the following:
   - A person's weight *(pounds in the United States, kilograms using the metric system)*
   - The distance you travel to school *(miles or kilometers)*
   - The speed you travel on the freeway *(miles per hour, kilometers per hour)*
   - The amount of energy in food *(calories)*
5. Share with students that electricity is measured in watts or kilowatts (1,000 watts = 1 kilowatt). It takes about 1 watt to power a small LED flashlight and 1.5 kilowatts (1500 watts) to power a hair dryer.[4] Explain that watts and kilowatts are a measure of electrical **power**, or *the rate at which energy flows.*
6. Show students the following formula and ask them how they could use it to convert electrical power into the amount of energy used *(multiply the total kilowatts or watts used by the amount of time).*

   Energy = Power × time
7. Invite students to first do an example with you. Have students use their handout to identify one type of light bulb found in your classroom along with its average wattage. Count the number of these light bulbs in use and estimate the number of hours these light bulbs are left on each day. Put this information into a table drawn on the board (similar to the one on their handout) and calculate total energy used together. For example:

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Appliance	Number	Hours In Use Per Day	Average Power Used (watts)	Divide by 1000 to Convert Watts to Kilowatts	Total Energy Used (E = Power × time)
Light bulbs (fluorescent)	10	× 8	× 32	÷ 1000	= 2.56

8. Repeat the example above assuming a different type of light bulb was in use. Compare the amount of energy used for the two types of light bulbs. Ask students which light bulb is more **energy efficient** *(completes the same task with less energy)* and would use less energy over an entire day.
9. Share the definition of **energy conservation** with students *(behaviors and actions that save or use less energy)*. Ask students what (if any) energy-conserving actions the school already does to conserve energy. Then ask students what actions you and the school could take in order to save energy on lighting *(for example, turning off the lights when no one is in the room, using only half of the lights when it is bright outside)*.
10. Give students 20 minutes to complete the handout *Personal Energy Audit*.

    Option: If desired, allow students access to computers in order to calculate their personal CO_2 emissions using National Geographic's *The Great Energy Challenge: Personal Energy Meter:* http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/global-personal-energy-meter/.
11. Bring the class back together to conduct a final questionnaire using the signs posted in the room or hallway. Read the following statements one at a time. After each question, you could ask a volunteer from each side to explain his or her answer. Highlight students who have changed their opinion since the initial questionnaire and ask them to explain their reasoning.
    - I will make an effort to turn off the lights when I leave an empty room.
    - The decisions I make about energy use can have a far-reaching impact.
    - Energy efficiency and energy conservation have different meanings.
    - Power and energy are the same thing.
    - I will encourage my peers to make better energy decisions.
12. Once the class has completed the questionnaire, have them return to their seats and use the questions below to guide a class discussion.

AMBER PARKIN

Discussion Questions

1. What most surprised you about your personal energy consumption?
2. What energy decisions do you make every day that influence society, the economy, and/or the environment?
3. Do you see opportunities in your home to conserve energy or use energy more efficiently? What about at school?
4. Do you think is easier for people to change their behavior or to buy more energy-efficient technologies in order to save energy? Why?
5. How is an individual's energy use a global issue?
6. How might your geographic location relate to the amount of electricity you use or to your CO_2 emissions? How do the types of energy sources used to produce your electricity impact your emissions?

Design and Engineering Extension

Have students research different weatherization techniques for homes. They can create a how-to guide for homeowners that teach specific ways to retrofit and conserve energy.

Service Learning Idea

Have students conduct an energy audit of their school. Students can analyze the data collected and brainstorm practical ways for their school to save more energy and money. They can formally present their findings at a public meeting or produce a written paper of their ideas to the school community. Encourage students to think of ways to incentivize these ideas to school administrators, teachers, and fellow students to adopt energy-saving behaviors. For example, students could calculate how much money could be saved in utility costs or the amount of carbon dioxide that would not be released. Students could also hold a community workshop to teach individuals how to save energy and money on their utility bills at home.

Additional Resources

- **Website:** *Standby Power*
  http://standby.lbl.gov/summary-table.html
  This website offers a summary of the extensive research conducted by Lawrence Berkeley National Laboratory on the amount of power consumed by appliances and electronics left in standby mode.
- **Article:** *Measuring Electricity*
  http://www.eia.gov/kids/resources/teachers/pdfs/MeasuringElectricityIntermediateSecondary.pdf
  A teaching resource from the U.S. Energy Information Administration's Energy Kids website describing how electricity is measured by volts, currents, power, and resistance.
- **Fact Sheets:** *Residential Energy Consumption Survey*
  http://www.eia.gov/consumption/residential/reports/2009/state_briefs/
  The *U.S. Energy Information Administration* has created several state-specific fact sheets on household energy consumption with information about types of fuel used in homes and how energy is consumed.

Name Date Class

Personal Energy Audit, page 1

An energy audit can help us determine how we use energy and how much energy we consume. With this assignment you will survey all the appliances found in your home that require electricity and take a look at your monthly electric bill. In class, you will use this data to calculate your personal energy use and consider how you may be able to conserve energy or use energy more efficiently.

Part I. Collecting Data (At Home)

Directions: Identify the different appliances that use electricity in your home. Estimate how many hours each appliance is in use during a 24-hour period. Use this information to complete the 2nd and 3rd column of the chart below.

- If there is an electrical appliance in your home that does not appear on this list, record this item under "Other" at the bottom of the chart and try to determine its wattage using the appliance's labels and manual.
- Be safe. Have an adult help you if you need to handle an appliance in order to determine its wattage.
- Some appliances may only be used for minutes at a time. Be sure to convert this time into units of an hour (for example, 15 minutes = 0.25 hours).

Appliance	Number	Hours In Use Each Day	Average Power Used (watts)[5]	Divide by 1000 to Convert Watts to Kilowatts	Total Energy Used (E = Power x time)
Air Conditioning					
Central A/C			5,000 watts	÷ 1000	
Window A/C			1,000 watts	÷ 1000	
Cell Phone Charger			5 watts[6]	÷ 1000	
Clock Radio			10 watts	÷ 1000	
Clothes Dryer			3,400 watts	÷ 1000	
Clothes Iron			1,400 watts	÷ 1000	
Clothes Washer			425 watts	÷ 1000	
Coffee Maker			1,050 watts	÷ 1000	
Computer					
Desktop			250 watts	÷ 1000	
Laptop			25 watts	÷ 1000	
Dishwasher			1,800 watts	÷ 1000	

Name Date Class

Personal Energy Audit, page 2

Appliance	Number	Hours In Use Each Day	Average Power Used (watts)[5]	Divide by 1000 to Convert Watts to Kilowatts	Total Energy Used (E = Power x time)
Fan					
Ceiling			120 watts	÷ 1000	
Window			150 watts	÷ 1000	
Furnace			750 watts	÷ 1000	
Whole House			500 watts	÷ 1000	
Game Console[7]					
Nintendo Wii			18 watts	÷ 1000	
PS2			30 watts	÷ 1000	
PS3			194 watts	÷ 1000	
Xbox			70 watts	÷ 1000	
Xbox 360			185 watts	÷ 1000	
Hair Dryer			1,600 watts	÷ 1000	
Light Bulb					
 Incandescent			60 watts	÷ 1000	
 Fluorescent			32 watts	÷ 1000	
 Compact Fluorescent (CFL)			14 watts	÷ 1000	
 LED			7 watts	÷ 1000	
 Halogen			60 watts	÷ 1000	

Name Date Class

Personal Energy Audit, page 3

Appliance	Number	Hours In Use Each Day	Average Power Used (watts)[5]	Divide by 1000 to Convert Watts to Kilowatts	Total Energy Used (E = Power x time)
Microwave			925 watts	÷ 1000	
Refrigerator			725 watts	÷ 1000	
Stereo			250 watts	÷ 1000	
Television 20-inch (LCD)			65 watts	÷ 1000	
26-inch (LCD)			110 watts	÷ 1000	
36-inch (Plasma)			250 watts	÷ 1000	
50-inch (Plasma)			350 watts	÷ 1000	
Toaster			1,100 watts	÷ 1000	
Vacuum			2,225 watts	÷ 1000	
Other				÷ 1000	

Part II. Reading Your Electric Bill (At Home)

Directions: Locate a copy of your monthly electric bill. Ask your parent/guardian for help if you do not know where to find the bill or are having trouble answering the following questions based on the bill's information.

1. How much do you pay for electricity for 1 month? *(This may be listed as "Amount Due," but check to see if your bill includes other utilities, such as gas, or if your bill covers more than 1 month.)*

____

2. How many kilowatt hours of electricity did your household use in 1 month? *(This may be listed as "meter usage," "recorded demand," "kWh usage," or "electricity usage.")*

____

3. What is the cost you pay per kilowatt hour? *(This may be listed along with the amount of kilowatt hours consumed. For example, "4,086 kWh @ $0.10.")* If you have trouble determining the cost you pay per kilowatt hour, you may use the national average: $0.1145.[8]

____

4. Can you tell from the bill if any or all of your electricity comes from renewable energy sources? *(You may pay extra to ensure a portion of your electricity come from renewable resources.)*

____

Bonus: You can get more insight into your long-term energy use patterns when you look at electric bills from multiple months. Determine an average for each of the above questions.

Personal Energy Audit, page 4

Bonus: Locate and analyze your natural gas, propane, or heating oil bills. You can calculate CO_2 emissions from these bills, along with your electric bill, using one of the following websites:

- What's My Carbon Footprint?™
  www.whatsmycarbonfootprint.com
- National Geographic: The Great Energy Challenge; Personal Energy Meter
  http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/global-personal-energy-meter/

Part III. Evaluating Your Energy Use (In Class)

Directions: Complete the chart from Part I by calculating the total energy used by each type of appliance using the following equation:

$$\text{Total Energy Used (in kilowatt hour)} = \frac{\text{\# of appliances} \times \text{hours used} \times \text{average wattage}}{1000}$$

Then use your findings to answer the questions below.

1. Evaluate the total amount of electricity used by different appliances. In your daily life, which type of activity seems to use the most energy? The least?

2. Based on data from the chart, estimate how much electricity your home uses in one month.

3. What information is not provided by your electric bill that your own calculations reveal?

4. If you wanted to estimate how much money a certain appliance costs you, how would you do it?

Name Date Class

Personal Energy Audit, page 5

5. Energy efficiency refers to completing a task using less energy input than usual. For example, an LED light bulb produces the same amount of light as other bulbs, but with less energy. Looking at the chart from Part I, where do you see opportunities to become more energy efficient?

6. Calculate the amount of energy you would use for lighting with and without LED light bulbs. What is the difference?

7. Energy conservation refers to behaviors and actions that people can do to save or use less energy. For example, turning off the lights when you leave a room is an action you can take that reduces the amount of electricity you use. Can you think of actions you could take to reduce the amount of energy you use?

8. Roberta is in the market for a new dishwasher! Her old dishwasher is leaking and she has been shopping around to find the best buy. One dishwasher she likes is energy efficient, but a bit more expensive. Using the idea of energy efficiency, what advice would you have for Roberta? Using the idea of energy conservation, can you suggest one behavior that Roberta could take to help her save electricity?

Bonus: One kilowatt-hour (kWh) of electricity equals 3,412 British Thermal Units (Btu). However, a fossil fuel-fired power plant uses 7,000-11,500 Btu of energy to create 1 kWh of electricity.[9] On average, how energy efficient (in percent) are fossil fuel-fired power plants? The formula for calculating the energy efficiency of a machine is:

$$\text{efficiency (\%)} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$$

Lesson 4

Toil for Oil

Students participate in an oil extraction simulation and experience the increasing difficulty of extracting a limited, nonrenewable resource over several years. Students consider the challenges posed by using nonrenewable sources of energy and then analyze global trends in oil production and consumption. On Day 2, they examine the history of oil dependence in the United States.

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Objectives

Students will:

- experience the increasing difficulty of extracting nonrenewable resources over time
- analyze global trends in oil production and consumption
- examine the history of oil dependence in the United States

Inquiry/Critical Thinking Questions

- What are some environmental, economic, and social consequences of relying on nonrenewable source of energy?
- What are global trends in oil production and consumption?
- What is the relationship between oil dependency and national security?

Time Required

Two 60-minute classes

Key Concepts

- **nonrenewable resource—**A limited resource, such as coal, natural gas, or oil that cannot be replaced as quickly as it is used.
- **petroleum (oil)—**A liquid fossil fuel and a nonrenewable energy source.
- **proved energy reserves—**The estimated amount of an energy resource that is currently available and recoverable with existing equipment and under existing conditions.
- **renewable resource—**A resource, such as biomass, sunlight, wind, or water, that can be replaced quickly and naturally.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.2 Human use of energy is subject to limits and constraints.

4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight.

6.4 Earth has limited energy resources.

7.1 Economic security is impacted by energy choices.

7.2 National security is impacted by energy choices.

7.4 Increasing demand for and limited supplies of fossil fuels affects quality of life.

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Materials/Preparation

1 notecard per student with "true" written on one side and "false" on the other side

1 pound of dried red beans per group of 12 students

1/3 cup of dried black beans per group of 12 students

1 medium size bowl per group of 12 students; put 1 pound of red beans and 1/3 cup black beans in each bowl

Timer or watch with a second hand to time activity

Overhead: *Estimated U.S. Energy Use in 2011* from Lawrence Livermore National Laboratory, https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2011/LLNLUSEnergy2011.pdf

Handout: *Oil Extraction Data Sheet*, 1 per student

Handout: *A Global Perspective*, 1 per student

Handout: *A History of Oil Dependency*, 1 per group of 4-5 students

Internet access for student activity on Day 2

Optional: Internet access to offer class additional background information

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Activity—Day 1

Introduction

1. Review the sources of energy that students read about during *Lesson 2: Power to the People!*

   Note: If you have not taught Lesson 2, then ask the class to brainstorm what sources of energy are used to generate electricity.

2. Show the class the overhead *Estimated U.S. Energy Use in 2011* and give students 2 minutes to examine it.
3. Ask the class the following:
   - Besides generating electricity, how else do we use these energy sources? *(transportation, industry, homes, commerce)*
   - Which energy source is used the most to meet our energy demands? *(petroleum)*
4. Ask students to define **petroleum**, or **oil** *(a liquid fossil fuel and a nonrenewable energy source).*
5. Pass out 1 true/false notecard per student.
6. Explain to students that you will ask them a series of true or false questions. They can respond by raising their notecard to show either the "true" or "false" side.
7. Read the following statements:
   - Fossil fuels are made from organisms that lived millions of years ago. Once these organisms died, they were covered with sediments and water. Millions of years of heat and pressure transformed these dead organisms into natural gas, petroleum, and coal *(true).*
   - Most oil is extracted by drilling through the earth to reach reserves *(true).*[1]
   - Things like gasoline, paints, plastics, eye glasses, heart valves, and CDs/DVDs can all be made from petroleum *(true).*[2]
   - The United States consumes 15% of the world's oil *(false, the United States consumes approximately 22% of the world's oil).*[3]
   - In 2009, the world consumed approximately 50 million barrels of petroleum per day *(false, in 2009, world consumption of petroleum was approximately 85.4 million barrels of petroleum per day, with the United States consuming 18.7 million barrels).*[4]

Steps

1. Tell the class that today they are going to "drill" for petroleum and model the extraction of oil reserves over 4 years.

   Option: To give students a sense of what drilling looks like, show them the following clip from The Discovery Channel's *Dirty Job* series, which focuses on oil drilling: http://dsc.discovery.com/tv-shows/dirty-jobs/videos/oil-drillers.htm.

2. Give each student 1 copy of the handout *Oil Extraction Data Sheet* and go over it as a class. Show them the bowls, explaining that the red beans represent soil and the black beans represent oil.

COURTESY OF PANAMA CANAL AUTHORITY

3. Divide your class into groups of 12. Each group of 12 represents an oil company. Within each group of 12, have the students count off by 4's. Students who count "one" will be workers that begin drilling in year 1. Students who count "two" will be workers that begin drilling in year 2, etc.
4. Place the bowls with beans on tables/desks in different areas of the room. Each oil company will gather around a separate bowl. Have the groups create a name for their oil company and record this on their worksheets.
5. When oil companies are situated and you have the timer ready, tell year 1 drillers to extract the oil by picking out black beans from the bowl and leaving red beans in the bowl. The drillers will have 45 seconds to extract oil while the remaining students observe this process.
6. At the end of the 45-second period, have students stop drilling and count the total barrels of oil their company extracted (each black bean is equal to 1 barrel of oil). Each member of the group should record this number, as well as the total number of drillers for year 1, on his/her *Oil Extraction Data Sheet.*
7. Have the same 3 students plus the year 2 drillers gather around the same bowls and repeat the activity for 45 more seconds, extracting and recording.
8. Repeat this procedure 2 more times to include year 3 and, finally, year 4 drillers.
9. Have students complete the *Oil Extraction Data Sheet* and then report the total number of barrels their company extracted and/or compile class data onto one chart.

   Option: You could create a line graph to visually depict this data and have students create a summary statement for the graph to share with the class. Provide a prompt for students such as:

   As the number of drillers and the amount of time increased, ____________.
10. In Think-Pair-Share format, ask students: Based on your data, would you classify petroleum as a renewable or nonrenewable resource? Why? *(Petroleum should be classified as a nonrenewable resource because eventually the amount of oil to be extracted decreased. Or, petroleum should be classified as nonrenewable because the black beans were not replaced as we extracted them.)*
11. Distribute the handout *A Global Perspective* to each student.
12. Ask students to look at the graph on page 1, *World petroleum consumption by region, 1980-2010.*[5]
13. Have them consider what this graph reveals about world and national oil consumption and answer questions at the bottom of page 1.

TONY LEUKERING

14. Share with students the definition of **proved energy reserves** *(the estimated amount of an energy resource that is currently available and recoverable with existing equipment and under existing conditions)*.
15. Have students look at the chart on page 2, *Oil Reserves by Country*, and answer questions based on the information they analyze.
16. In Think-Pair-Share format, have students use both the graph and the chart to compare the amount of oil reserves of a country to the amount of oil consumed by that country.
17. Ask students what the connection is between the drilling for oil activity and their analysis of global trends in oil production and consumption.
18. Lead students in the discussion questions below.

Discussion Questions

1. What happens when a nonrenewable resource is extracted over several generations?
2. How might the nonrenewable nature of petroleum influence the technology developed to extract it?
3. What might happen to the price of petroleum as it becomes increasingly difficult to extract? Why? How might this impact you and your family's life?
4. What factors might contribute to high oil consumption in North America?
5. How can individuals respond to these factors in order to lower our consumption of oil?

Activity—Day 2

Steps

1. Tell students that in 1977, President Jimmy Carter made the following statement regarding energy policy in the United States:

   The oil and natural gas we rely on for 75 percent of our energy are running out. In spite of increased effort, domestic production has been dropping steadily at about six percent a year. Imports have doubled in the last five years. Our nation's independence of economic and political action is becoming increasingly constrained. Unless profound changes are made to lower oil consumption, we now believe that early in the 1980s the world will be demanding more oil that it can produce.[6]

   Option: Share the entire speech, and have students analyze the main message. The speech can be found here: **http://www.youtube.com/watch?v=-tPePpMxJaA**

2. Ask students the following questions:
   - Why do you think oil and natural gas in United States was running out?
   - Why did oil imports double over the last five years (from 1972 to 1977)?
   - What might happen when there is more demand for oil than the world is capable of producing?
   - What is the history of oil dependency in the United States?


BETSY J. ENSLIN

- How could changes in the price of oil affect a family's life?

3. Students may be unsure of answers at this stage. Explain to them that, in small groups, they will learn the history of oil dependence and U.S. foreign policy to understand the relevance of Jimmy Carter's speech on energy policy.
4. Split students into 6 small groups of 4-5 students. Explain that each group will analyze a portion of a timeline of events related to oil dependency and U.S. foreign policy created by Toni Johnson. The timeline can be found on the U.S. Council on Foreign Relations website: **http://www.cfr.org/energyenvironment/timeline-oil-dependence-us-foreign-policy/p24322**.

   Option: If students don't have internet access, print out the different parts of each historic period to share with each group.
5. Divide students into research teams who will look at the following categories on the timeline:
   - Rise of the Oil Commodity (from The Black Gold Rush to The Red Line Agreement)
   - Rise of the Oil Commodity (from Oil Quotas to the End of the War)
   - Age of Oil Competition (from The Marshall Plan to the First Arab Oil Embargo)
   - Age of Oil Competition (from the Tehran and Tripoli Agreements to the Crisis of Confidence)
   - Deregulation and Diversification (from the Iran-Iraq War to the Birth of the Super Majors)
   - Deregulation and Diversification (from the New Assertive Oil Powers to U.S. Releases Oil from Strategic Reserve)
6. Pass out the *A History of Oil Dependency* handout and have students follow the directions to complete the handout.
7. After students have completed the handouts, bring the class back together. Each group can present a summary of what they learned from their specific time period.
8. Culminate the activity with the discussion questions below.

Discussion Questions

1. What is the relationship between oil and international relations?
2. What relationships might exist between energy and economic growth?
3. What historic events encouraged U.S. dependency on oil?
4. What kind of U.S. policy on oil use would be economically, socially, and environmentally sustainable?

WYATT WELLMAN

5. How do current lifestyles "demand" oil? Or, how do our attitudes and behaviors about energy impact oil supply?
6. How do you think technology has affected the use of oil as a primary energy source in the United States? In turn, how did the use of oil impact the types of technology created?

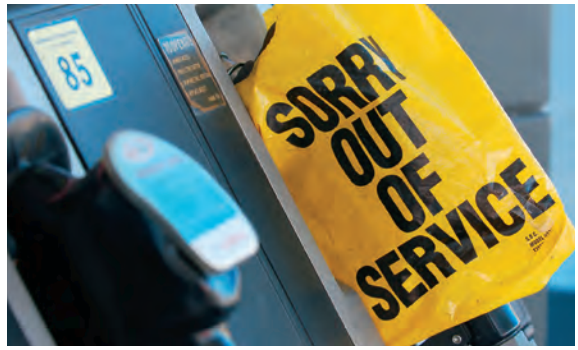
Science and Technology Extension

Have students research hydraulic fracturing (a.k.a. fracking) technology used to extract natural gas (another fossil fuel) in order to explore how extraction technology has changed. The following are a few resources students could use to research. Because these extraction techniques can be controversial, you may want to prepare students to look for bias in the resources they choose.

- **Website:** *Energy Kids*
  http://www.eia.gov/kids/energy.cfm?page=natural_gas_home-basics
  This U.S. Energy Information Administration website provides kid-friendly information about natural gas, how technology to extract natural gas has changed, and the environmental impacts of extracting this natural resource.
- **Article:** *What is shale gas and why is it important?*
  http://www.eia.gov/energy_in_brief/about_shale_gas.cfm
  This article by the U.S. Energy Information Administration provides a map of where shale gas is found in the United States, a diagram of the extraction process, and information on environmental issues.
- **Interactive Website:** *Extracting Natural Gas from Rock*
  http://www.nytimes.com/interactive/2011/02/27/us/fracking.html
  Extracting Natural Gas From Rock is an interactive look at the steps used in hydraulic fracturing.

Student research and reporting can be guided by the following questions:

- What is hydraulic fracturing and how is it different from traditional methods of natural gas extraction?
- How do you think the nonrenewable nature of natural gas has affected the development of new extraction technology?
- How do you think science has influenced the creation of new extraction techniques?
- What are some of the economic, social, and environmental benefits and risks of hydraulic fracturing?



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Service Learning Idea

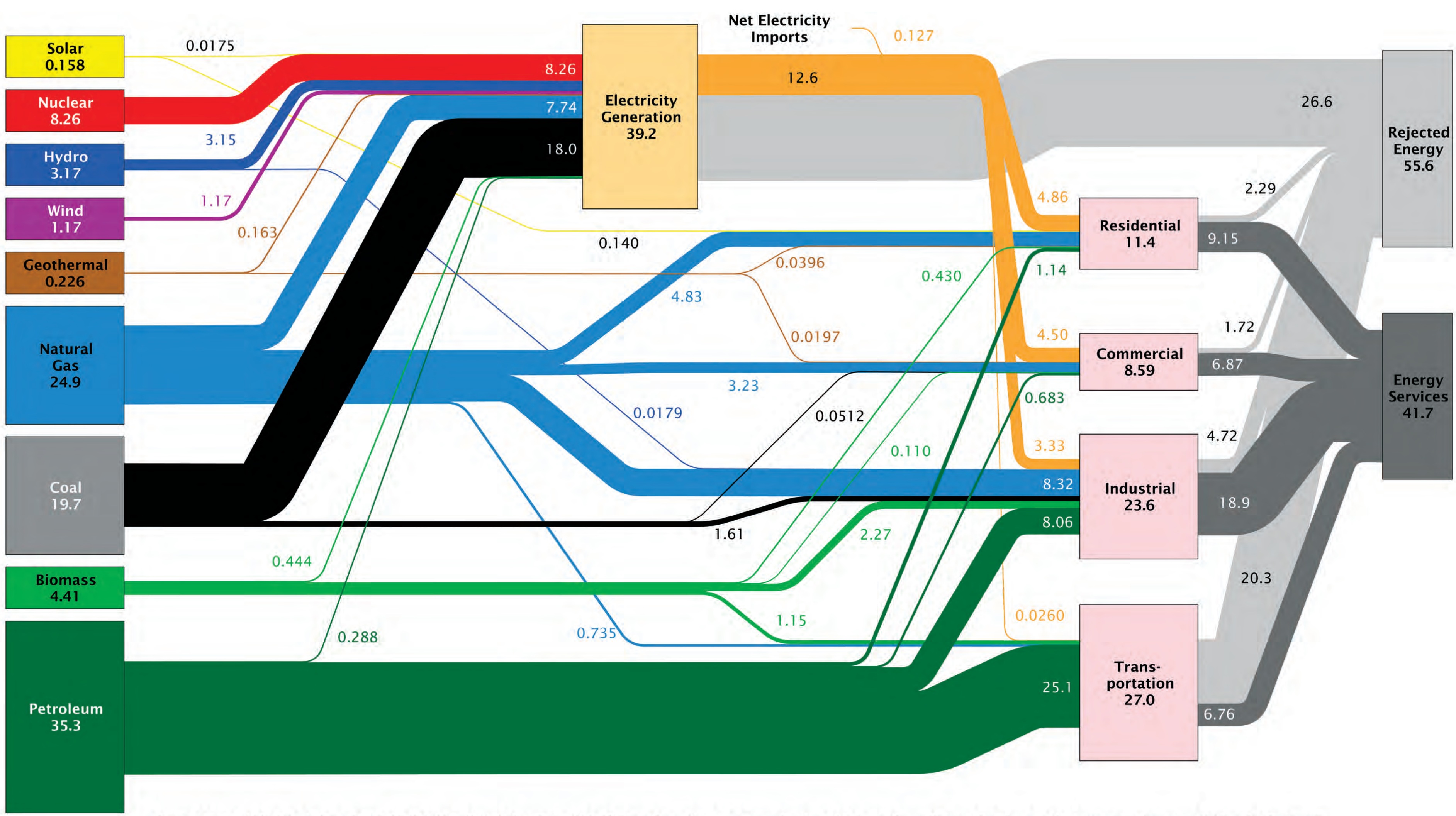
Students conduct an interview with a person born in an earlier generation, such as a grandparent or parent, about changes in availability, price, or use of fuels and petroleum-based products such as gas, plastics, or synthetic clothing. Possible interview questions:

- Are there any energy resources that are less available now than they were when you were younger? What are some of these resources?
- How has this affected you and your community?
- How have prices for energy resources or petroleum-based products changed in your lifetime? Can you recall how much a gallon of gasoline cost when you were my age?
- Do you ever think about future generations when you use energy resources? Do you think more people should think about this?

Additional Resources

- **Article:** *'Peak Oil' is a Waste of Energy*
  http://www.nytimes.com/2009/08/25/opinion/25lynch.html
  In this *New York Times* Op-Ed article, energy consultant Michael Lynch continues the debate on whether we should be concerned about oil reserves. He questions whether we are truly facing a peak oil crisis. Students can read both sides of the debate to get the big picture about what is happening.
- **Graphics:** *Running Dry*
  http://www.economist.com/blogs/dailychart/2011/06/oil-production-and-consumption
  These graphics created by *The Economist* look at oil production and consumption around the world. Students can compare the differences between both.
- **Presidential Speech:** *America's Energy Security*
  http://www.whitehouse.gov/photos-and-video/video/2011/03/30/america-s-energy-security#transcript
  A 47-minute speech by President Obama on March 30, 2011 at Georgetown University.

Estimated U.S. Energy Use in 2011



Source: LLNL 2012. Data is based on DOE/EIA-0384(2011), October, 2012. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Lawrence Livermore National Laboratory

Oil Extraction Data Sheet

Student Name: ____________________

Oil Company: ____________________

Directions: Keep track of your oil company's total barrel extraction using the following table. You should record the total number of barrels (black beans) extracted each year from all drillers in your company. Each black bean is equal to 1 barrel of oil.

	Year 1	Year 2	Year 3	Year 4
Total Barrels of Oil Extracted by Your Oil Company				
Total Number of Drillers				

1. Describe what happened to the amount of oil extracted over the 4 years.

____

____

2. How did the number of drillers relate to the amount of oil extracted?

____

____

3. What could cause a need for more drillers or more oil extraction?

____

____

4. Predict what would happen to the amount of oil if you continued this activity for several more years and continued to add more drillers each year.

____

____

5. Based on your results, would you conclude that oil is a renewable or nonrenewable resource? Support your answer with evidence from the table above.

- **nonrenewable resource**—A limited resource that cannot be replaced as quickly as it is used.
- **renewable resource**—A resource that can be replaced quickly and naturally.

____

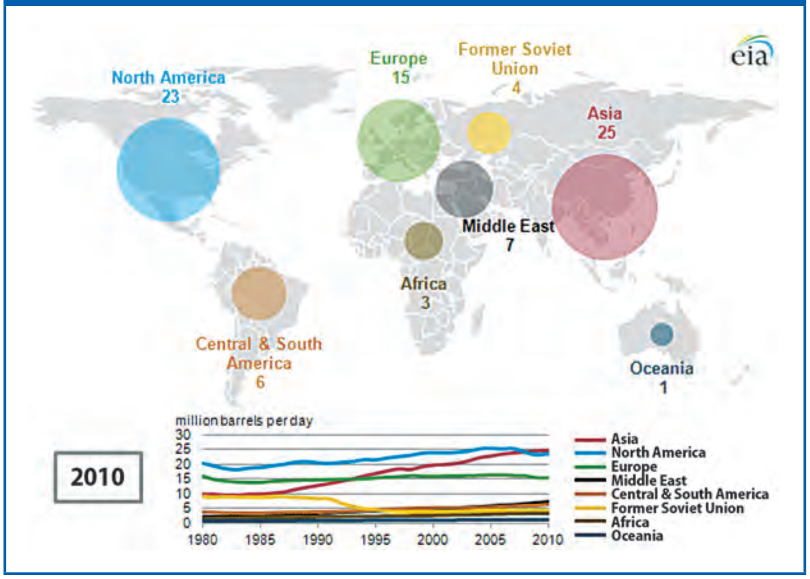
____

Name Date Class

A Global Perspective, page 1

Directions: Use the following data to answer the questions below.

World Petroleum Consumption by Region, 1980–2010
(million barrels per day)



SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION

1. Which region consumes the most petroleum?

2. Why do you think this region consumes the most petroleum?

3. Which region consumes the least petroleum?

4. Why do you think this region consumes the least petroleum?

Name Date Class

A Global Perspective, page 2

Directions: Use the data from page 1 and the following table to answer the questions below.

Oil Reserves by Country

Rank	Country	Crude Oil in Barrels
1	Saudi Arabia	262,600,000,000
2	Venezuela	211,200,000,000
3	Canada	175,200,000,000
4	Iran	137,000,000,000
5	Iraq	115,000,000,000
6	Kuwait	104,000,000,000
7	United Arab Emirates	97,800,000,000
8	Russia	60,000,000,000
9	Libya	46,420,000,000
10	Nigeria	37,200,000,000
11	Kazakhstan	30,000,000,000
12	Qatar	25,380,000,000
13	United States	20,680,000,000

SOURCE: CENTRAL INTELLIGENCE AGENCY'S WORLD FACTBOOK.

1. What do you notice about the countries that have the most oil reserves and the countries that consume the most petroleum? Why do you think this is the case?

2. In 1967, Israel engaged in a conflict with Egypt, Syria, and Jordan known as the Six Day War. Soon after, Arab oil ministers declared a trade embargo on any countries friendly to Israel. Suddenly, oil shipments stopped going to the United States and Britain.[7]

- Based on the graph and chart above, what impacts do you think an oil embargo would have on a country like the United States?
- What connections do you see between oil and international relations?

Name Date Class

A History of Oil Dependency, page 1

Directions: In small groups, you will research a specific historic time period and learn more about oil dependency during these time periods. Follow the steps below to complete this assignment.

1. Visit the U.S. Council on Foreign Relations' website to locate Toni Johnson's "Timeline: Oil Dependence and U.S. Foreign Policy." http://www.cfr.org/energyenvironment/timeline-oil-dependence-us-foreign-policy/p24322

2. Based on the historic period you have been given by your teacher, click on one of the three links:
   - Rise of the Oil Commodity
   - Age of Oil Competition
   - Deregulation and Diversification

3. Use the information from your portion of the timeline to complete the chart below:

Date	Event(s)	Relevant leaders/ countries involved	Impacts	Questions/ Wonderings

Name Date Class

A History of Oil Dependency, page 2

Date	Event(s)	Relevant leaders/ countries involved	Impacts	Questions/ Wonderings

4. Summarize the connection between oil and international relations during the time period you studied.

Lesson 5

Energizing the World

Students use graphs and statistics to learn about energy use around the world and consider sustainable energy solutions. They read a country profile to examine energy issues such as access, reliability, and energy-efficient infrastructure. Then students connect their research with the United Nations' Sustainable Energy for All initiative and work together in small groups to create a public service announcement (PSA) that encourages people and governments around the world to work toward sustainable energy solutions.

SHERRY DECKMAN

Objectives

Students will:

- analyze total and per capita energy use for different countries
- understand the diverse energy needs of people around the world
- draw connections between energy use and sustainability
- create a PSA that encourages people to work toward sustainable energy solutions

Inquiry/Critical Thinking Questions

- What are current global energy issues?
- How can all humans meet their basic energy needs while ensuring that the energy needs of future generations will be met?
- How could people be encouraged to use energy more sustainably?

Time Required

Two 60-minute classes

Key Concepts

- **energy access**—Having reliable and affordable energy services such as household access to electricity as well as cooking fuels and stoves that do not cause indoor air pollution.
- **energy efficiency**—Completing a specific task with less energy input than usual, such as using an energy-efficient LED light bulb which uses less energy than other light bulbs to produce the same amount of light.
- **energy reliability**—The degree to which an energy system, such as an electric grid, is able to deliver energy within accepted standards, especially when the system is under stress.
- **infrastructure**—The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communication systems, water, power lines, and public institutions such as schools, post offices, and libraries.
- **leapfrog technology**—An advanced technology that is transferred to a lesser developed country or region, allowing that region to rapidly adopt more suitable or sustainable modern systems without going through intermediate stages.
- **per capita**—An average per person.
- **personal solution**—An action an individual can take to alleviate a problem.
- **structural solution**—A solution that make changes within a system in order to alleviate a problem.

TERRY RICH

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

5.1 Decisions concerning the use of energy resources are made at many levels.

5.2 Energy infrastructure has inertia.

6.2 One way to manage energy resources is through conservation.

6.3 Human demand for energy is increasing.

6.4 Earth has limited energy resources.

6.5 Social and technological innovation affects the amount of energy used by human society.

7.3 Environmental quality is impacted by energy choices.

7.4 Increasing demand for and limited supplies of fossil fuels affects quality of life.

7.5 Access to energy resources affects quality of life.

7.6 Some populations are more vulnerable to impacts of energy choices than others.

Materials/Preparation

Overhead: *Energy Consumption: Choosing Your Lens*

Handout: *Energy Profile,* 1 country per student

Handout: *Energy Profile Jigsaw,* 1 per student

Handout: *Sustainable Energy for All,* 1 per group

Internet access to share an online video with the class

Optional: Internet access for further research, 1 computer per small group

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Activity—Day 1

Introduction

1. Ask the class the following questions:
    - What factors might affect how much energy a country uses? *(population, industry, energy infrastructure, natural resources)*
    - How do you think the amount of energy consumed in our country compares to other countries? Why?
2. Display the overhead *Energy Consumption: Choosing Your Lens.* Show only the first graph ("Total Energy Used per Country"). Do not yet reveal the second graph.
3. Discuss the significance of the break in the graph.
4. In Think-Pair-Share format, ask students to analyze the graphs and answer the following questions:
    - Which countries on the graph use the most energy? The least energy?
    - What might be some reasons for this difference in energy use? *(differences in population, technology, lifestyle, access to energy sources, etc.)*
5. Now show the class the second graph, "Total Energy Used per Capita." Ask students what they think **per capita** means and how it might be determined. *(Per capita means per person. The amount of energy used per capita can be calculated by dividing the total amount of energy consumed in a country by that country's population.)*
6. In Think-Pair-Share format, ask students to analyze the graphs to answer the following questions:
    - On average, the residents of which countries use the most amount of energy? The least amount of energy?
    - How does this compare to the total energy used by each country?
    - What might be some reasons for the differences between these two graphs?
    - What information is not given by a per capita average?
    - What are some drawbacks to relying on per capita data when analyzing a country's energy use?
7. Share with the class that they will now take a closer look at how energy is used in a few particular countries to better understand how energy is consumed around the world.

Steps

1. Divide the class into groups of 4 and give each student within a group a different *Energy Profile* handout. Ensure that each group receives a profile for each of the 4 different countries. Give each student 1 copy of the handout *Energy Profile Jigsaw* and discuss the directions.

    Option: In place of reading the *Energy Profile* handout, students can conduct research about the energy use and needs of 1 country on the Energy Profile Jigsaw

DAVE WILTON

(India, Kenya, Russia, the United States). Provide the following questions for guidance:

- Do most people in the country have access to electricity? If so, what sources of energy do they use to provide electricity and is their access to electricity reliable? If not, what other forms of energy do they use?
- Does living in an urban or rural area of this country determine their access to energy and energy sources?
- What forms of nonrenewable energy does this country rely upon?
- What forms of renewable energy does this country rely upon?
- What is the energy infrastructure (e.g., electric grid) like in this country?
- What sort of energy issues does this country face?
- What sort of energy solutions is this country attempting?

Have students focus on the following issues for each specific country:

- India: biomass, power outages, growing population, developing economy
- Kenya: hydropower, limited energy access, intermittent power, biomass
- Russia: fuel diversity, energy exports, risks of nuclear energy, inefficient energy use
- United States: aging energy infrastructure, high per capita energy consumption, renewable energies

The following websites may prove useful for student research:

- *Central Intelligence Agency: The World Factbook*
  https://www.cia.gov/library/publications/the-world-factbook/index.html
- *The World Bank: World Development Indicators*
  http://data.worldbank.org/news/new-suite-of-world-development-Indicators-products-now-available
- *National Geographic: Global Electricity Outlook*
  http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/world-electricity-mix/
- *Reegle: Country Clean Energy Information*
  http://www.reegle.info/countries
- *U.S. Energy Information Administration: Country Data and Analysis Briefs*
  http://www.eia.gov/countries/index.cfm
- *International Energy Agency: Country Profiles*
  http://www.iea.org/countries/

2. Give the class about 15 minutes to individually read their assigned *Energy Profile* and record notes in the column for that country on the handout *Energy Profile Jigsaw*. Having students write their thoughts for solutions (in the last column of the handout *Energy Profile Jigsaw*) after they've finished reading and taking notes on their assigned Energy Profile.

CROOKED TRAILS

3. After 15 minutes, instruct each student to summarize aloud what they have learned about their country's energy issues while the other students in their group record this information on their *Energy Profile Jigsaw* handout. Once all students have shared their summaries, the group should come up with a response for the following questions:
   - What are some of the most surprising facts you learned?
   - What are 3 critical energy issues we face today, as a global community?
   - Why do these energy issues need to be addressed?
   - How do you think these issues should be addressed?
4. Bring the class back together and have groups share their answers to these questions. Record the critical energy issues that students name to revisit on the second day of the lesson.
5. Collect student handouts and conclude with the discussion questions below.

Discussion Questions

1. How is energy consumption a global issue?
2. How does energy use play a role in environmental, social, and economic development?
3. What might be some of the environmental, social, and economic consequences of unsustainable energy practices?
4. Do per capita statistics offer a holistic understanding of the energy needs and issues of a particular country?
5. How do different energy resources relate to quality of life?
6. How would your own life be different if your access to electricity was intermittent or unreliable?

Activity—Day 2

Introduction

1. Show the class 1 or both of the following online videos about energy:
   - *Sustainable Energy Services for All*
     http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/focus_areas/sustainable-energy.html
     This 30-second PSA was created by the United Nations Development Programme to promote access to clean energy around the world.
   - *We Care: The Solar Suitcase*
     http://vimeo.com/46117446#
     This 3-minute clip shares Laura Stachel's experience working as a gynecologist in Nigeria and how it motivated her and her husband to develop a simple solar energy unit for hospitals or clinics that lack reliable access to electricity.
2. Ask the class the following questions:
   - What is the purpose of this public service announcement (PSA)?

TANZANIA/© 2003 SARAH BONES/CARE

- What type of audience do you think PSAs like this are created for?
- What types of solutions are suggested by this PSA?
- How effective do you think this PSA is? Do you have suggestions for making it more effective?

Steps

1. Review the global energy issues students identified on Day 1 of the lesson.
2. Have students get back into the groups of 4 that they worked in on Day 1.
3. Give each student the handout *Sustainable Energy for All* and allow groups time to read it.

   Option: Alternatively, students could read the Secretary-General's Vision Statement for this United Nations initiative online: http://www.sustainableenergyforall.org/.
4. Once students are finished with the reading, have the class summarize the initiative's 3 main objectives and compare them to the global energy issues they identified on the first day of the lesson.
5. Discuss the difference between personal and structural solutions.
   - **personal solutions**—Actions an individual can take to alleviate a problem.
   - **structural solutions**—Solutions that make changes within a system in order to alleviate a problem.
6. Tell the class to imagine that the UN Secretary-General Ban Ki-moon has invited youth from around the world to get involved in the Sustainable Energy for All global initiative. Explain that today they will work in small groups to conduct further research on the 3 main objectives of the initiative and to write a script for a 60-second public service announcement that encourages people around the world to take action to achieve sustainable energy for all by 2030.

   Option: If desired, you can allow students more time to produce their PSA as a video or audio recording and share it with the school.
7. Share the following guidelines with students. Each PSA should:
   - Clearly state the energy issue it asks people to address (e.g., greater access to electricity in rural areas, more energy conservation behaviors at home)
   - Include a persuasive environmental, economic, and social argument for why people should care and take action
   - Identify at least 1 personal and 1 structural solution that can address the issue (encourage students to think of creative solutions that were not mentioned in the reading)
8. Bring the class back together and have groups present their PSAs to the class.
9. Conclude with the discussion questions below.

KARL VOELKER

Discussion Questions

1. How could you take action to help achieve sustainable energy for all by 2030?
2. Sustainability means meeting current needs without compromising the ability of future generations to meet their needs. What might prevent people and countries from using energy sustainably? How would you address this?
3. How could countries with fewer resources and lower Gross National Incomes (GNIs) meet their energy needs in a sustainable way?

   Note: You could introduce and discuss the concept of leapfrog technology here. **Leapfrog technology** is an advanced technology that is transferred to a lesser developed country or region, allowing it to rapidly adopt more suitable or sustainable modern systems without going through intermediate stages.
4. How do personal and structural solutions to energy issues compare? What personal and structural solutions could you participate in?
5. Can you think of a situation in which reducing energy use would lead to an increased quality of life?
6. Do you think energy is a basic human right? Why or why not?

Social Studies Extension

Have students watch a TED talk by Hans Rosling, *The magic washing machine,* (http://www.ted.com/talks/hans_rosling_and_the_magic_washing_machine.html). Students can analyze Hans Rosling's point of view and determine whether they agree or disagree with this perspective related to energy use, economics, and consumption.

Service Learning Idea

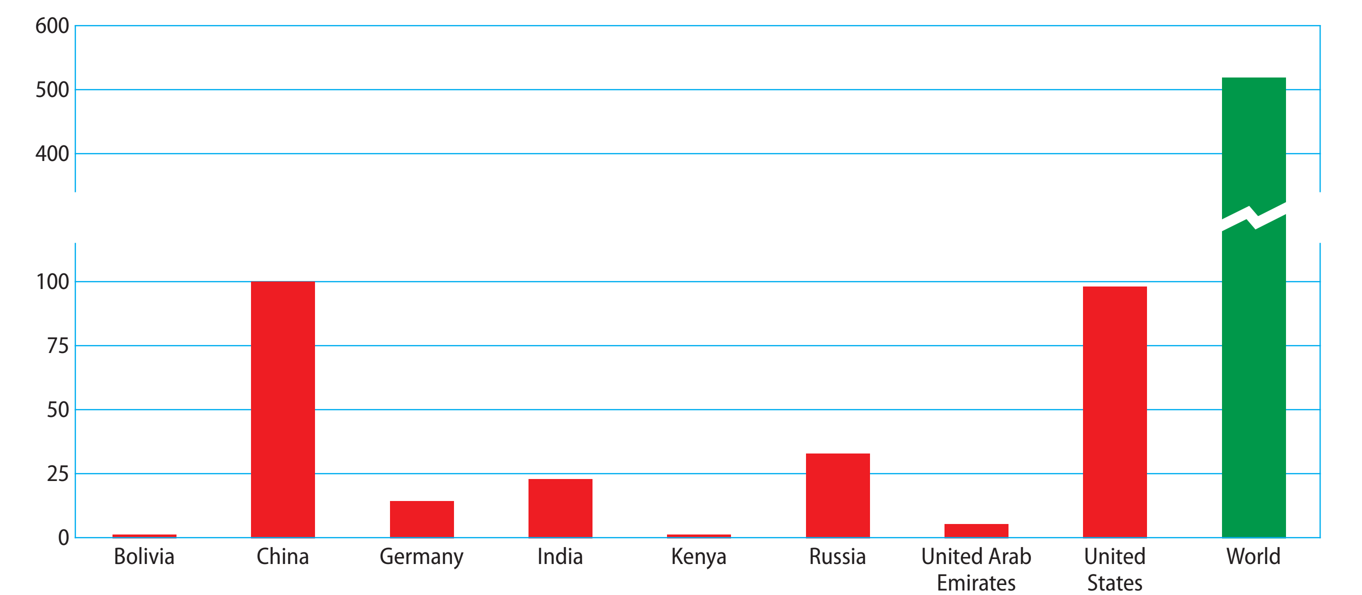
Have students educate their school and/or local community about ways to achieve sustainable energy for all. Have students record their PSAs and share with the school or with local media.

Additional Resources

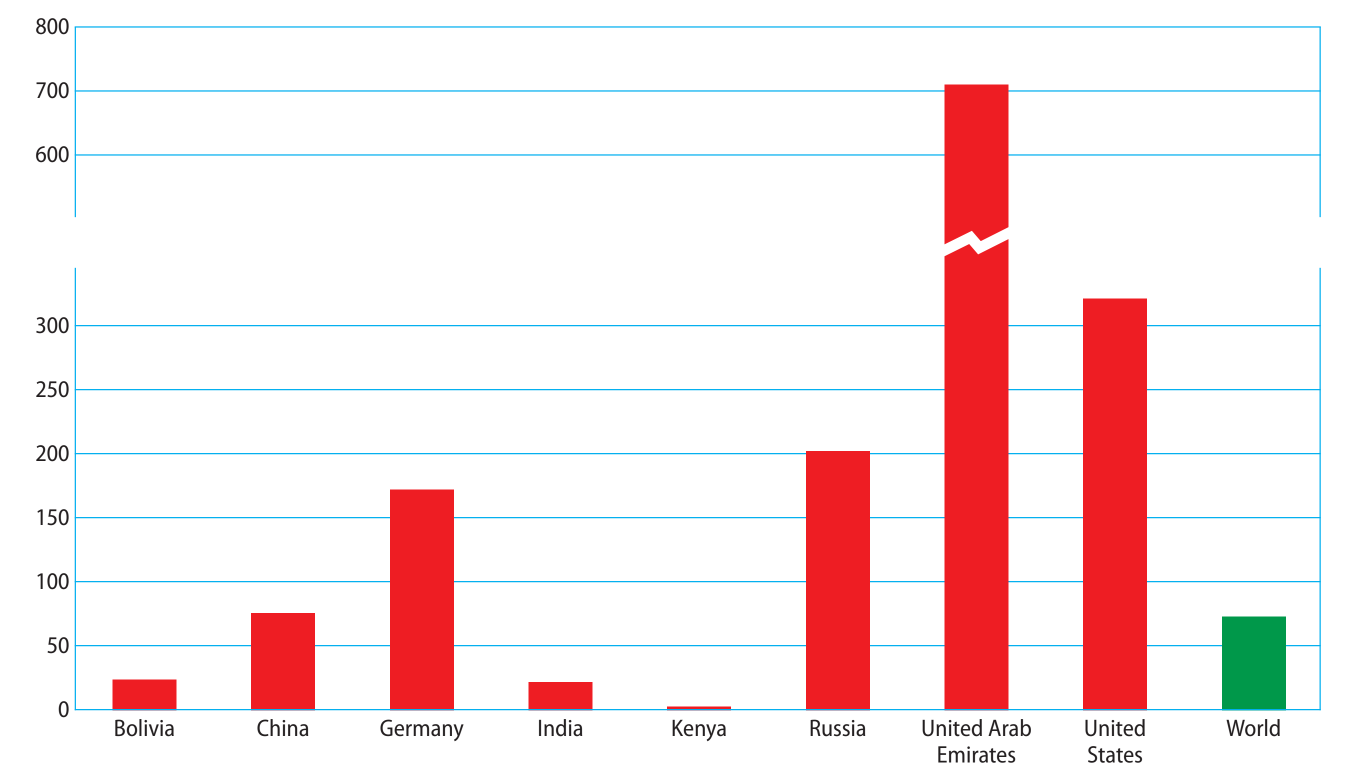
- **Website:** *Sustainable Energy for All*
  http://www.sustainableenergyforall.org/
  This website describes the global initiative set forth by UN Secretary-General Ban Ki-moon to make sustainable energy accessible to everyone by 2030, and provides many resources for further research.
- **Fact Sheets:** *Residential Energy Consumption Survey*
  http://www.eia.gov/consumption/residential/reports/2009/state_briefs/
  The *U.S. Energy Information Administration* has created several state-specific fact sheets on household energy consumption with information about types of fuel used in homes and how energy is consumed.

Energy Consumption: Choosing Your Lens

Total Energy Used per Country (Quadrillion Btu)



Total Energy Used per Capita (Million Btu)



Source: "Total Energy," EIA, under International Energy Statistics, accessed April 18, 2013, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=2.

Energy Profile: India

A young person living in a rural village in India may spend hours each day collecting firewood to cook and heat his or her home. This prevents some youth from going to school. In addition, burning firewood inside the home without enough ventilation can cause serious respiratory illnesses. Rural areas face other problems that stem from poor energy access. At night, families may use dim kerosene lamps for light. This may be the only light that young people can use to study or do homework. But kerosene fuel can be expensive for a family with a limited income and the fumes cause respiratory and vision health problems.

In contrast, a young person from a wealthy or middle class household living in an urban area likely uses other energy sources, like electricity. India is undergoing rapid urbanization, which increases the country's demand for energy. The demand for electricity in cities across India has increased. For example, in the city of Hyderabad, in southern India, more people are using air-conditioning, refrigerators, televisions, and lighting.[1] But as electricity use increases, blackouts become more common as demand for energy goes beyond what the electric grid is capable of providing the area. In 2012, a massive power outage affected nearly half of the 1.2 billion people living in India for several hours.[2]

In 2011, India was the world's fourth largest consumer of energy, after the United States, China, and Russia. The country's economy is undergoing a shift from agriculture to industry. As a result, transportation and electricity needs are growing. Most of India's electricity is produced by domestic sources of coal. India relies heavily on petroleum imports as well.

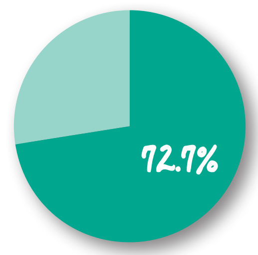
As India's population and economy continue to grow, the demand for energy will increase as well. Even with India's increased investment in renewable energy such as wind, demand could outpace the country's domestic energy supply.

Fast Facts*

Access to Electricity
(% of population in 2009)
66.3%

Electric Power Consumption
per capita (2010)
616.2 kWh

Fossil Fuel Consumption



(% of total energy consumed in 2010)

Average CO_2 Emissions
per Capita (2009)
1.6 METRIC TONS

Gross National Income
per Capita (2011, Atlas model)
$1,410/YEAR

* "World Development Indicators," World Bank Database, accessed April 5, 2013, http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators.

Energy Profile: Kenya

A young person from a wealthy or middle class family living in Nairobi, the capital city of Kenya, probably has access to electricity. Approximately 25% of Kenyans are connected to the electric grid and most of those people live in cities.[3] One of the energy issues in urban areas of Kenya is that the power frequently goes out. Nairobi's electricity is mainly generated by hydropower. While hydropower creates less pollution than fossil fuels, a source of energy that is dependent on rainfall can be problematic in East Africa. Rainfall in the region can be infrequent and droughts cause electricity blackouts that may last for hours each day. Blackouts impact young peoples' ability to study for school at night. Blackouts can also affect hospitals and restaurants that need to keep medicine and food refrigerated to prevent it from spoiling.

Many rural parts of the country are not connected to the electric grid. For young people living in rural villages, kerosene lamps have been the only option to provide lighting, even though kerosene lamps can cause vision and respiratory issues.[4] Urban residents without access to electricity face a similar situation. Many poor rural Kenyans move to cities in search of jobs and end up living in slums because they can't afford apartments or houses. In Nairobi, approximately 60% of people live in slums where they have little or no access to electricity.[5] In recent years, people have developed LED lamps in response to these issues. LED lamps are very efficient at using electricity, either from an outlet or battery.

As Kenya's economy develops and its population continues to grow, demand for electricity is rising. At the same time, climate change may impact the reliability of hydropower, because a changing climate can alter rainfall patterns and affect stream flow. In times of drought, the country must use imported petroleum to generate electricity. The Kenyan government, concerned about the high cost of oil imports and rising greenhouse gas emissions, has begun to promote and invest in alternative energy sources.

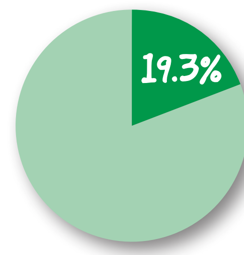
Due to Kenya's geography, solar and wind power are possible renewable energy options. In 2012, development of the largest wind farm in sub-Saharan Africa began in Kenya. This wind farm is approximately 40,000 acres and will operate 365 wind turbines.[6] Wind farms can be linked to the electric grid as well as provide energy to rural areas without access to the electrical grid.

Fast Facts*

Access to Electricity
(% of population in 2009)
16.1%

Electric Power Consumption
per capita (2010)
156 kWh

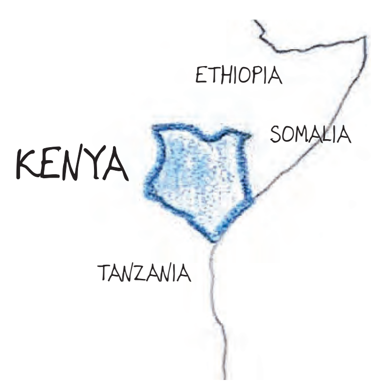
Fossil Fuel Consumption



(% of total energy consumed in 2010)

Average CO_2 Emissions
per Capita (2009)
0.3 METRIC TONS

Gross National Income
per Capita (2011, Atlas model)
$820/YEAR



* "World Development Indicators," World Bank Database, accessed April 5, 2013, http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators.

Energy Profile: Russia

A young person in an urban area of Russia, such as Novosibirsk or St. Petersburg, typically lives in a small apartment with many members of his or her family. These apartments are the most common form of housing in Russian cities because the Soviet Union developed large, uniform apartment complexes in an attempt to provide everyone access to housing. Russian winters can be frigid, although the temperature will vary in different parts of the country. While electricity is generally reliable, local governments may regulate energy use in winter, limiting when the heat can be turned on and how much heat can be used. Some families buy portable electric heaters to keep their homes a little warmer.

In contrast, a young person living in a rural area of Russia, such as parts of Siberia, may not have access to the electric grid. Rural families often heat their homes using coal or firewood. Siberia is home to one-fifth of the world's forests, so firewood is one local resource that provides heat for many.

Russia is an energy-rich country—one of the biggest producers of natural gas, oil, and coal in the world. Russia's economy relies heavily on energy exports. The country is also dependent on fossil fuels for its own energy needs. About half of the energy consumed in Russia comes from natural gas.[7] Most of this energy is used to support Russia's industrial sector.

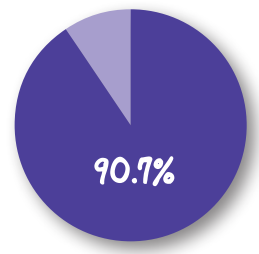
Russia also uses nuclear power and hydropower to support its energy needs, but currently relies little on other renewable sources of energy. Nuclear power can have dangerous consequences if not well regulated. In 1986, a reactor exploded at the Chernobyl Nuclear Power Plant in the Ukraine, then part of the Soviet Union, releasing a large amount of radiation. Many people died and many more became sick. Radioactive contamination remains a problem in the area to this day.

Another energy issue facing the country is energy efficiency. Enough energy is wasted in Russia in 1 year to power all of France.[8] Much of this inefficiency is due to Russia's old and unreliable energy infrastructure. In 2008, former Russian President Dmitri Medvedev announced a national goal to cut energy waste by 40% by 2020.[9]

Fast Facts*

Electric Power Consumption
per capita (2010)
6,430.6 kWh

Fossil Fuel Consumption



(% of total energy consumed in 2010)

Average CO_2 Emissions
per Capita (2009)
11.1 METRIC TONS

Gross National Income
per Capita (2011, Atlas model)
$10,650/YEAR

* "World Development Indicators," World Bank Database, accessed April 5, 2013, http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators.

Energy Profile: United States

The amount of energy used by a young person in the United States can be different depending on the climate where she or he lives. Winters are longer and colder in the Northeast or Midwest compared to the Southwest or Southeast, and during cold winters people often use more energy to heat their homes. Most homes in the United States are heated by electricity or natural gas. Energy is also used in homes for lighting, air conditioning, hot water, electronics, and appliances. In the United States, the amount of electronics that young people have in their homes has increased in the last few decades—it is now common for households to have more than one TV or computer.[10]

Transportation is another way young people use energy in the United States. While some youth may walk or take public transportation, others ride to school in their family's car. Families that live in rural areas may have to drive farther to get to work and school than families that live in cities. Over the last few years, rising gas prices have sometimes meant financial hardship for those families that have longer commutes or lower incomes. Often families with the lowest incomes end up spending a greater portion of their income on energy needs than others.[11]

Most young people live in places that are connected to the electrical grid. In other words, their homes are connected to wires that carry electricity from their local power plant. However, some young people living in rural areas may not be connected to the electrical grid. Instead of electricity or natural gas, they may use propane (another form of gas) to heat their homes or diesel to power electric generators.[12] Other families may not be able to afford the cost of electricity or fuel.

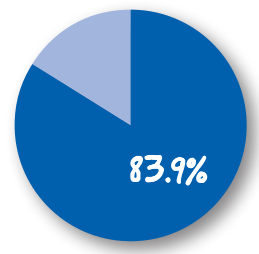
The country's current electric grid was built in 1890. It wastes a lot of electricity and is hard to control. As the aging system faces additional stress from growing demand for energy, blackouts and brownouts are increasing. For instance, on August 14, 2003, one power line problem coupled with high energy demand left around 45 million people in the United States and 10 million people in Canada without power.[13] Power outages like this are not only inconvenient, but they have economic consequences, too. In this case, the economic loss in the affected area was $6 billion.[14] One thing the United States could do to update its energy infrastructure is create a smart grid. New technologies such as a smart grid can monitor the amount of electricity people are using and sense problems with transmission lines. A smart grid can automatically fix problems or re-route electricity in the case of emergencies as well as monitor and save energy on a daily basis.[15]

Fast Facts*

Access to Electricity
(% of population in 2009)
97%

Electric Power Consumption
per capita (2010)
13,393.9 kWh

Fossil Fuel Consumption



(% of total energy consumed in 2010)

Average CO_2 Emissions
per Capita (2009)
17.3 METRIC TONS

Gross National Income
per Capita (2011, Atlas model)
$48,620/YEAR

* "World Development Indicators," World Bank Database, accessed April 5, 2013, http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators.

Name Date Class

Energy Profile Jigsaw

Directions: Use the table below to record information about energy use as it relates to environment, economy, and society for your assigned country. Then consider what sustainable energy solution may be appropriate in addressing your assigned country's energy issues. As you learn about other countries from your group members, complete the rest of this table.

	India	Kenya	Russia	The United States
Environment (e.g., carbon emissions, renewable energy, deforestation)				
Economy (e.g., economic development, employment)				
Society (e.g., health, well-being, education)				
Solutions (e.g., technology-based, conservation-minded, or access-oriented)				

Sustainable Energy for All

In 2011, United Nations Secretary-General Ban Ki-moon declared a global initiative to achieve Sustainable Energy for All by the year 2030. The initiative grew out of widespread recognition that access to clean and affordable energy is central to efforts to alleviate poverty, work toward social equity, and grow developing economies. At the same time, the initiative also recognized the importance of making our modern energy systems more sustainable. To achieve these goals, the UN is building a coalition of governments, businesses, and civil society partners to ensure that all people have access to sustainable energy, defined as "energy that is accessible, cleaner, and more efficient."[16]

Around the world, many energy needs are going unmet. About 3 billion people (nearly 40% of the world's population) use traditional biomass to cook and heat their homes. Traditional biomass refers to fuel such as wood, charcoal, animal dung, or coal. Overuse of wood in some areas has led to deforestation and environmental degradation. Also, burning this type of fuel on inefficient cook stoves can lead to very poor indoor air quality and, therefore, serious health problems. In fact, almost 2 million people each year die prematurely from illnesses related to poor indoor air quality.[17]

Additionally, there are about 1.4 billion people that have no access to electricity and about 1 billion more whose access to electricity is unreliable.[18] Reliable access to electricity and clean burning fuels and stoves are important for human health, economic stability, and quality of life. For example, electricity is used to power water pumps that help people get clean water and irrigate land. Electricity lights schools and refrigerates vaccines in health clinics. The poor are often most affected by lack of access to electricity or the electric grid. An electric grid refers to the infrastructure (such as power lines and transformers) needed to transmit and distribute electricity to consumers. The electric power grid often does not reach the homes of the rural poor. In urban areas, poor households may not have official connections to the electric grid and the poor often cannot rely on constant access to electricity.[19]

Many people around the world do already have access to reliable electricity and clean cooking facilities. While this may contribute positively to the social and economic well-being of these individuals and countries, this energy often comes from nonrenewable, polluting sources. Large amounts of fossil fuels are used to generate electricity and fuel cars. When fossil fuels are burned, it releases greenhouse gas emissions that contribute to climate change. Many countries are also faced with aging energy infrastructure (such as power lines and power plants) that is inefficient and wastes large amounts of energy.

The proponents of the Sustainable Energy for All global initiative believe that if we all work together change can happen. There are things that people can do at local, national, regional, and international levels to use energy more sustainably. There are new, innovative technologies that use renewable sources of energy, such as the sun, to provide people in the most remote regions with power and economic opportunity without needing to connect them to a large electric grid. These leapfrog technologies are advanced technologies transferred to a lesser developed country or region, allowing it to rapidly adopt more suitable or sustainable modern systems without going through intermediate stages. For example, developing countries could build energy infrastructure that can handle renewable sources of energy rather than fossil fuels, or build smaller electric grid systems that are easier to update rather than one large grid. The Sustainable Energy for All initiative invites all sectors of society to help achieve 3 main objectives:

- Make sure all have access to modern energy services.
- Double the efficiency power grids and systems.
- Double the percent of renewable energy in the global energy supply.[20]

Lesson 6

Fueling the Future

Students begin this lesson by examining the characteristics of 2 different transportation fuels—one a biofuel and one created from crude oil—to evaluate their sustainability. Students learn the definition of sustainability and its 3 key components: economy, environment, and society. Students then discuss and evaluate the sustainability of various feedstocks used to produce transportation fuels.

TRAVPHO, ISTOCK

Objectives

Students will:

- define sustainability and its 3 components: economy, environment, and society
- evaluate from multiple perspectives the sustainability of extracting or growing various feedstocks
- understand that fuel consumption has local and global impacts

Inquiry/Critical Thinking Questions

- What does sustainability mean and how does it relate to human activity?
- What are the impacts of different transportation fuel feedstocks on societies, environments, and economies?

Time Required

One 60-minute class

Key Concepts

- **economy**—The system of production, distribution, and consumption of goods and services.
- **environment**—The surroundings or ecological conditions in which a person, animal, or plant lives or operates.
- **feedstock**—The raw material used in manufacturing or processing.
- **fuel**—Material such as gasoline that can be burned to produce energy.
- **society**—A community, nation, or other group of people who have common interests, institutions, or culture.
- **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

5.4 Energy decisions are influenced by economic factors.

5.5 Energy decisions are influenced by environmental factors.

5.6 Energy decisions are influenced by social factors.

7.1 Economic security is impacted by energy choices.

7.3 Environmental quality is impacted by energy choices.

7.6 Some populations are more vulnerable to impacts of energy choices than others.

Materials/Preparation

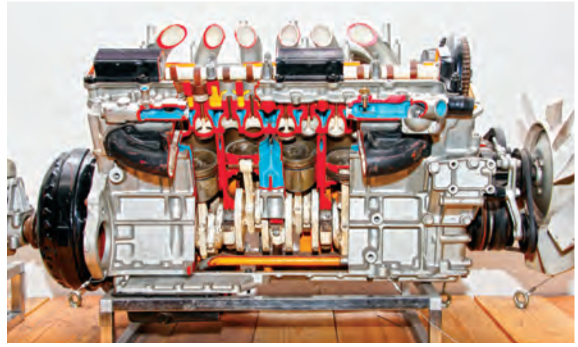
Before class, gather examples or pictures of corn, sugarcane, and wood products.

Overhead: *Consumer's Choice*

Overhead: *Components of Sustainability*

Cards: *Feedstocks & Sustainability,* 1 sheet per group of 4 students (cut out role cards on each sheet and give 1 to each student in the group)

Handout: *Is it Sustainable?*, 1 per group



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Activity

Introduction

1. Ask students what factors people consider when they make decisions about what fuels to use in their vehicles *(responses may include proximity, price, or the type of car)*.
2. In Think-Pair-Share format, have students review the definition of sustainability.
   - **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.
3. Ask students what connections they think there are between sustainability and fuel choice.
4. Display only the first row of the overhead *Consumer's Choice* to show the price at the pump for Fuel 1 and Fuel 2 (do not reveal any other rows at this time):
   - **Price at the Pump:** This describes the cost of a fuel per unit of volume (e.g. price per gallon).
5. Ask the class:
   - Which fuel do you think is more sustainable ? Why?
   - What additional information would you want to know about each fuel to make a more informed decision regarding its sustainability?

   Note: You may want to record these characteristics on the board.
6. Reveal the remaining rows on the overhead, listed below, one at a time. After each reveal, ask students which fuel is more sustainable and why. Let the class know that there is not a right answer, but they should be able to justify their ideas. Students will likely change their opinion at least once as more information is provided.
   - **Price per Unit of Energy:** This row describes the cost of a fuel per unit of energy, which is a British thermal unit (BTU). The amount of energy in one gallon of fuel varies depending on fuel type.
   - **Miles to Closest Fuel Station:** Some alternative fuels are not found at every gas station. The U.S. Department of Energy provides an online *Alternative Fuels Data Center* (**http://www.afdc.energy.gov/locator/stations/**) to help consumers find gas stations that offer alternative fuels or electric charging stations.
   - **Flex Fuel Car Required?:** Vehicles may require slight modifications at the factory in order to use alternative fuels. Flex fuel capable vehicles can take a larger amount of ethanol blended into gasoline than conventional vehicles.
   - **Type of Feedstock:** This describes the energy source used to produce the fuel. Crude oil, or petroleum, is the most common feedstock in the United States for transportation fuels.
   - **Fuel Type:** Gasoline is the most common fuel used in cars today. Other fuel types used include diesel, liquefied petroleum, compressed natural gas, and ethanol.
7. Reflect on this activity with the following questions:
   - Did you change your mind during this activity about which fuel was more sustainable? If so, what information caused you to change your mind?

MARCO SCIFONI

- What information do consumers receive about fuels at a gas station? Is this enough to determine which fuel is most sustainable?
- What do you think is included in or determines the cost of fuel?

Steps

1. Find and show students pictures or examples of different kinds of feedstocks: an ear of corn, sugarcane, and/or a wood product. Ask students whether each is a source of potential energy (stored energy) or kinetic energy (energy of movement). *(Each is a source of potential chemical energy that can be converted to a liquid transportation fuel.)*
2. Tell students there are many different types of feedstock that can be converted to transportation fuels. Explain that the feedstock most commonly used for transportation in the United States is petroleum. However, there has been a push to shift towards using alternative feedstocks in the past several years.
3. Ask students why they believe this may be the case. *(This will be further explored in Lesson 7. For now, some ideas may include that petroleum is a nonrenewable resource. Because of its scarcity, there has been a push to ensure that the United States is energy secure and not depending on a resource that will not be available in the future as the demand for fuel increases. Petroleum use is also connected to increased CO_2 emissions.)*
4. Share with students that today they will evaluate the sustainability of different feedstocks used to produce transportation fuels.
5. Explain that a common way to determine whether an activity or product is sustainable is to evaluate how it impacts the economy, environment, and society.

   Note: You may need to define economy, environment, and society.
6. Ask the class why they think it is important to consider these 3 areas when determining the sustainability of a good such as fuel.
7. Show the overhead *Components of Sustainability* to students.
8. Explain that when students are evaluating the sustainability of a feedstock, they should consider the local impacts of where the feedstock is extracted and the impacts of where the feedstock is consumed and used.

   Option: Share the following *New York Times* article by Elisabeth Rosenthal, "As Biofuel Demand Grows, So Do Guatemala's Hunger Pangs" (**http://www.nytimes.com/2013/01/06/science/earth/in-fields-and-markets-guatemalans-feel-squeeze-of-biofuel-demand.html**). This article examines a few perspectives of the impacts of the growing demand for biofuels and how this demand is in conflict with the needs of food-based agriculture.


TERRY RICH

9. Divide the class into groups of 4 students each. Give students the following instructions: Each of you will receive a role card that provides some information about your perspective on the extraction or growth of a particular feedstock used to produce transportation fuel. Each person should read their role card aloud to the group; throughout the activity, try to retain the perspective presented on your role card. You will work together as a group to determine how resource extraction impacts the long-term well-being of people and the planet by completing the handout *Is It Sustainable?* Your group should discuss the pros and cons of your feedstock and reach consensus to recommend whether or not extraction of the resource should continue. Choose one person in your group to record answers on the handout and another person to report to the class your group's analysis of your feedstock's sustainability.
10. Hand out *Feedstocks & Sustainability* role cards to each group so that one group has 4 different role cards for crude oil/petroleum, another group has 4 different role cards for corn, and so on.

    Note: Remind students that these cards represent just a few perspectives and only a handful of feedstock types. In other words, not all views are represented.
11. Pass out the handout *Is It Sustainable?* to each group.
12. Allow groups ample time to read their roles and work through the handout together. Leave 10-15 minutes at the end of class for each group to share their analysis of the sustainability of their fuel feedstock. The following questions can help guide group presentations:
    - What is the resource and how is it currently extracted/grown?
    - Is it extracted/grown sustainably?
    - If not, how could it become more sustainable?
13. Wrap up with a short class discussion using one or more of the discussion questions below.

Discussion Questions

1. What is sustainability and how does it relate to fuel?
2. Which transportation fuel appears to be the most sustainable choice? Which appears to be the least sustainable choice? Why?
3. What drives fuel production? How do consumers play a role?
4. Besides creating alternative fuel sources, what are some other ways that individuals and communities can promote more sustainable travel? Encourage students to think of energy efficiency and energy conservation.
5. What are some variables that might affect whether or not a feedstock is produced sustainably? Is it possible that there could be both sustainable and unsustainable ways of producing the same type of fuel? How?

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6. Whose needs should be met when there are trade-offs involved (e.g., between economic and environmental priorities)? How can these situations be resolved in a way that addresses everyone's concerns?

Science and Technology Extension

In addition to alternative fuel sources, we can make transportation more sustainable by increasing the fuel efficiency of cars. Have students research how things like body shape, weight, and tires can be designed to be more fuel efficient. You might encourage students to use biomimicry as an inspiration. Consider creating real life constraints for students such as the environment for which the car is designed (e.g., off road, city, or freeway) or the purpose of the car (long-distance travel or speed). Alternatively, students can design and race 2 cars online using an activity from The Lawrence Hall of Science and compare their mileage, safety, cost, and pollution.

- **Website:** *The Lawrence Hall of Science: 24/7 Science*
  http://www.lawrencehallofscience.org/kidsite/
  Look for and click on *Car Comparison* under the *Arcade Games* heading.
- **Website:** *Designboom®: Biomimicry*
  http://www.designboom.com/contemporary/biomimicry.html
  Students can read about biomimicry and how it can be used to design more efficient technology, including examples of how nature inspired the design of the bullet train in Japan and a Mercedes-Benz concept car.

Service Learning Idea

Students research persuasive tactics that help to influence behavior change. They can then create a strategic campaign that educates the community about how to decrease energy use related to transportation.

Additional Resources

- **Video:** *Converting Biomass to Liquid Fuels*
  http://www.nrel.gov/learning/re_biofuels.html
  This video from the National Renewable Energy Laboratory shows the process by which plants become fuel.
- **Article:** *Rush to Use Crops as Fuel Raises Food Prices and Hunger Fears*
  http://www.nytimes.com/2011/04/07/science/earth/07cassava.html
  This *New York Times* article offers perspectives on the social and economic consequences of biofuels.
- **Film:** *Cows and Cars*
  http://releasd.com/Ss8w/bp-cows-cars
  This documentary examines how biofuels created sustainability can have positive social and environmental results.
- **Animation:** *Biofuels Feedstocks*
  http://www.bp.com/liveassets/bp_internet/globalbp/STAGING/global_assets/complex_flash/bp_complex/MainMovie6.swf
  This animation provides a brief overview of several different energy feedstocks.

Consumer's Choice

	Fuel 1	Fuel 2
Price at the Pump[1]	$3.52 per gallon	$3.24 per gallon
Price per Unit of Energy[2]	$30.52 per million BTU	$39.69 per million BTU
Miles to Closest Fuel Station[3]	0.4 miles	24 miles
Flex Fuel Car Required?	No	Yes
Type of Feedstock	Petroleum	Sugarcane
Fuel Type	Regular gasoline	Ethanol (E85)

Components of Sustainability

Society

- How are people's lives affected?
- How are cultures affected?
- Do some people benefit at the expense of others?

Environment

- How are living organisms affected?
- How are air, water, and soil affected?
- What is the long-term impact on the environment?

Economy

- How are local, national, and international economies affected?
- What is the cost-benefit?
- Is there a long-term economic gain for people and communities?

Feedstocks & Sustainability, page 1

Group A: Crude Oil

I am a **MARINE BIOLOGIST**. I study organisms that live in the oceans. Crude oil drilling like the kind that happens off the coast of Texas and Louisiana worries me. Oil rigs that house the machinery used to drill for petroleum in the ocean floor can be damaged by hurricanes, causing crude oil to spill into ocean waters. There is also a risk of spills when oil is transported by ship from one place to another. When oil enters a marine ecosystem, it can be disastrous. Aquatic birds, mammals, and fish can all become covered in the thick oil, leading to death in some cases. Even when crude oil is extracted safely, its use has been linked to climate change, which also impacts our oceans. Climate change causes oceans to become warmer and more acidic, endangering sensitive species like coral.

I am an **OIL COMPANY SPOKESPERSON**. I believe that crude oil is the most efficient fuel source for our nation's transportation needs. We already have the technology and infrastructure in place to use crude oil for creating diesel, gasoline, and jet fuel. By drilling off the coast of the United States, we reduce our need for foreign oil. This is much safer than relying on oil from countries that may have unstable governments. Very few accidents have occurred in recent years, demonstrating the safety of the oil drilling industry. Plus, it provides many jobs in the United States.

I am a **ROUGHNECK ON AN OIL RIG**. It's a tough job, but it pays well. You have to be in good shape to work on an oil rig, that's for sure! I help to set up and carry out the drilling. I'm responsible for maintaining the pipes that carry the oil; I constantly check to make sure there are no leaks. I also help with mechanical maintenance, like making sure the engine is working right. Our rig runs all the time, so I work long hours. My family wishes I spent more time at home. Every once in a while I hear about an accident where a rig blew up or about a storm that sank a rig into the ocean. Those accidents can be fatal for the crew on the rig. I hope I can keep working on the oil rig, though, because it offers good wages for people who don't have college degrees or specialized training. All of the factory jobs in my hometown have been moved overseas, so this job is even more important now.

I am an **ALTERNATIVE FUELS INVESTOR**. I fund research on alternative fuels so that we can do all the things we love to do without relying on crude oil. While most people think the only way we can move our cars is with gasoline that comes from crude oil, I have found that there are quite a few other options that could be affordable and profitable. Creating biofuels from biomass is one option. Though biofuels create air pollution like gasoline does, their feedstocks absorb carbon dioxide from the atmosphere when they are regrown. This helps to offset the carbon dioxide emitted into the air and could help fight climate change. Or, perhaps electric cars could be the wave of the future, especially in places where electricity is provided by renewable fuel sources like wind power. All you need to do to power an electric car is to recharge its batteries after use. Another possibility is hydrogen fuel cells. These amazing devices convert hydrogen and oxygen into water, producing electricity in the process.

Feedstocks & Sustainability, page 2

Group B: Sugarcane

I am an **INDIGENOUS PERSON** whose family has lived in the same forest in Brazil for hundreds of years. We use the land to grow cassava, corn, beans, and squash. In recent years, different groups have wanted to use our land to grow sugarcane instead. Sugarcane farmers and landowners have occupied our land and cut down our forests, forcing many of us off the land. This has had a major impact on our way of life and driven many indigenous families into poverty. Without other options, some of us are forced to work on sugarcane plantations for low wages. This exhausting manual labor involves cutting down sugarcane with a machete for up to 12 hours a day.[4] The forests where we live provide indigenous people with the resources to support ourselves and maintain our culture. We must protect our land.

I'm a **CAR OWNER** from Brazil. Just a few years ago, my government introduced flex fuel vehicles and I purchased a car. These flex fuel vehicles run on either gasoline blends or pure ethanol made from sugarcane. I can now choose the type of fuel I want at the gas station. Like most of my friends and family, I choose sugarcane ethanol because it's affordable and I've read research on how it's also good for the environment. Because of demand from consumers like me, approximately 90% of cars made in Brazil today are flex fuel vehicles.[5]

I'm the **CEO OF A BIOFUEL COMPANY** based in Brazil. Sugarcane ethanol is the most environmentally safe fuel source for our country's transportation needs. In 1975, the National Ethanol Program helped to increase the use of ethanol in Brazil.[6] These days, my company collaborates with aviation and automotive companies, crop technology developers, biofuel producers, government representatives, and environmental agencies to create more efficient biofuels. Biofuels have had a positive impact on Brazil's economy. Sugar and ethanol production represent 3% of the gross domestic product. There are significantly more jobs available than there were when Brazil produced oil.[7]

I am a **FARMER** in Brazil. In the past, farmers like me used to provide corn, beans, and coffee to local markets. However, in the past three decades, things have changed dramatically. During the 1970s, a sugarcane mill came to our community to create biofuels that could replace oil. In theory, this was a great way to limit our dependency on oil; however, I've seen the impacts on my community and the environment. Sugarcane production has almost entirely replaced food production. Forests were cut down in order to plant large areas with this monocrop. This area was once rich in fauna and flora, but now it is barren. Less and less land is available for farming and food prices have increased significantly. The sugarcane mills use heavy machinery to prepare land, causing soil erosion.[8] Sugarcane mills surrounding our community spread pesticides by airplane and we have seen health impacts like asthma, lung disease, and cancer. Environmentalists have also shared how we are losing carbon stocks when the forests are cut down.

Group C: Corn

I am an **ETHANOL PLANT WORKER** in Minnesota. A few years ago, hundreds of ethanol plants were created in states that grew lots of corn. This was an exciting time because these plants offered jobs to so many people. Small towns that had suffered economically in the past were finally starting to do well. Overall, the ethanol industry employs approximately 200,000 people. Because of biofuels like ethanol, the United States also saves $2 billion a year due to reduced oil imports.[9] In the last couple of years, I've been concerned about my job security. Droughts throughout the Midwest have meant smaller corn harvests. I've heard that a few ethanol plants have started to shut down. Hopefully my job won't be threatened, but the excitement around ethanol production has certainly decreased in recent times.

I am a **FARMER** in Iowa. Because I grow corn, in recent years I've benefitted from government incentives to promote biofuels. As part of the Farm Bill passed in 2002, the government provides subsidies for growing corn. In other words, the government pays farmers to grow corn—$20 billion each year, in fact. The government subsidizes corn in large part because it is used to make biofuels. Within a short time, it looks like 50% of all corn crops will be needed to create biofuels.[10] Other government policies, like the Energy Policy Act of 2005, also help support more corn production. The Act states that billions of gallons of ethanol must be blended in vehicle fuel each year.[11] Biofuel producers in the United States who buy my corn also get extra support from the government. There is a tariff on the import of biofuels from other countries, making it difficult for foreign companies to enter the U.S. market.[12]

I am an **ECONOMIST** from the World Bank who studies international poverty and development. I have analyzed trends in biofuel production in recent years. United States produced approximately 13.7 billion gallons of ethanol recently which is almost nine times the amount it produced in 2000.[13] By 2010, 6% of global grain consumption went to U.S. biofuel production and 40% of corn grown in the United States was used for ethanol. Because of increasing demand for biofuels, there has been greater competition for land to grow biofuel crops in place of food crops. Food prices have started to go up, resulting in more hunger around the world. My recommendation is that the United States uses the parts of corn that are not needed for food. Biofuels can also be created from corn stalks to produce cellulosic ethanol which can save food parts for human consumption. However, this is a more complex process that is not yet as economical as using corn starch.[14]

I work for the **U.S. DEPARTMENT OF ENERGY**. We are working to reduce the U.S. dependence on oil imported from other countries. If these countries were to stop producing oil, then we would be in a tough place. We want to make sure that the United States has strong energy security, meaning the country has a constant and reliable supply to meet our energy needs. One way to do this is to create our own biofuels from crops like corn. By investing in biofuels within the United States, we can increase the domestic production of transportation fuels, help build rural economies by creating more jobs, and decrease the environmental impacts of the energy we use. In partnership with the U.S. Department of Agriculture, we have decided to invest $41 million in projects to help grow the biofuels industry.[15]

Group D: Woody Biomass

I am **LOGGER** in Washington state. I make my living by harvesting trees. In the past, these trees were used for all sorts of things everyone needs, like furniture, construction materials, magazines, tissues, and toilet paper. Lately, there has been an increased demand to use the biomass from forests, wood process industries, and recycled wood products for the purpose of creating biofuels. This has increased job opportunities for people in my community. Loggers believe it is important to maintain a healthy forest industry. Forests are home to 90% of the biodiversity on land.[16]

I am a member of a **TRIBAL GROUP** that has lived near the same Pacific Northwest forest for hundreds of years. The forest provides us with food, shelter, and medicines. Trees are one of our most valuable natural resources and have great cultural significance. When we make decisions regarding how we share this natural resource, we consider many factors: our economic needs, our society and culture, and the impact on the environment. Our tribe manages approximately 255,000 acres of forestland. We take great pride in being stewards of the land. We are working with a number of different groups to consider how the waste wood found throughout our forests could be used as a viable option for the biofuel industry. If more of our fuels came from woody biomass, it could help to greatly support employment for our tribes.[17]

I am a representative of the **AVIATION INDUSTRY** in the northwestern United States. We are working with different groups like the Navy, Air Force, and university researchers to help develop sustainable biofuels. One of the universities we work with has been given a $40 million grant to focus on creating sustainably grown wood energy crops for transportation fuels.[18] Our hope is that the creation of alternative biofuels would give us a choice about fuel. Right now, the only option we have is petroleum-based jet fuel. Woody biomass is abundant in the Pacific Northwest region and this resource provides an opportunity for us to create sustainable biofuels. We believe that transitioning to the use of biofuels will help to support local economies by creating jobs and meeting a growing consumer demand.

I am an **ENVIRONMENTAL SCIENTIST**. I study the impacts of increased woody biomass use for biofuels. Using woody biomass residues for energy is using biomass that would have typically been burned or decomposed. Using them for biofuels avoids uncontrolled air pollutant emissions from open burning. However, this does raise a concern about the sustainability of removing residues from the forest. If residues become this valuable and profitable, will too many be removed therefore impacting forest soil health? Bioenergy producers say they will rely only on residues and not on entire trees, but rising prices could mean a shift in forest practices to shorter more intensive harvest rotations if whole trees are used. This could have impacts on carbon storage, wildlife habitat, and water quality.

Is It Sustainable?

Group Members: ______________________________

Feedstock: ______________________________

1. What are the environmental impacts of extracting this resource?

____

____

2. Overall, is this feedstock **environmentally** sustainable?

a. Why, or why not? ______________________________

____

b. How could it be made more sustainable? ______________________________

____

3. How does the use of this feedstock affect local and national economies?

____

____

4. Overall, is this feedstock **economically** sustainable?

a. Why, or why not? ______________________________

____

b. How could it be made more sustainable? ______________________________

____

5. How does the use of this feedstock impact people and communities?

____

____

6. Overall, is this feedstock **socially** sustainable?

a. Why, or why not? ______________________________

____

b. How could it be made more sustainable? ______________________________

____

7. On a scale of 1-5, where 1 is not sustainable at all and 5 is completely sustainable, rate the overall sustainability of this feedstock.

NOT SUSTAINABLE				COMPLETELY SUSTAINABLE
1	2	3	4	5

Performance-based Assessment

Sustainable Flight in the Pacific Northwest

The following performance-based assessment (PBA) for this unit is designed to assess student learning of content and skills through multiple products. The assessment's driving question is based on an authentic real-life question facing stakeholders in the Pacific Northwest region of the United States. The PBA is intended to motivate students to be active participants in the learning process. The PBA is designed to be conducted with Lessons 7, 8, and 9. You can familiarize yourself with the assessment here prior to teaching the lessons.

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Driving Question

- What are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation?

Time Required

5 days (an additional day can be added if you want students to write the final position paper in class)

Suggested Scope and Sequence

Day 1	Lesson 7
Day 2	Lesson 8
Day 3	Lesson 8
Day 4	Lesson 9
Day 5	Lesson 9

Materials/Preparation

Background preparation: The 3 lessons below incorporate the content necessary for students to complete the performance-based assessment. Review the lessons and the packet before introducing the assessment to students.

Lesson 7: *The Sky's the Limit*

Lesson 8: *The Life of a Fuel*

Lesson 9: *Sustainable Flight: A Stakeholder Meeting*

Packet: *Sustainable Flight in the Pacific Northwest*, 1 per student

The packet includes the following:

- *Scoring Sheet*
- *Scenario: Sustainable Flight in the Pacific Northwest*
- *Product 1: The Life of a Fuel Poster* (Group)
- *Product 2: Supply Chain Evaluation* (Individual)
- *Product 3: Stakeholder Position Analysis* (Group)
- *Product 4: Council Member Negotiation* (Group)
- *Product 5: Negotiation Self-Assessment* (Individual)
- *Product 6: Final Recommendation Paper* (Individual)

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Introducing this Assessment

This performance-based assessment (PBA) has been designed to engage students in tackling a complex, real-world energy issue facing society today—developing alternatives to fossil fuels. Currently, the aviation industry has no viable alternative to petroleum-based fuel and many people are working toward the development of aviation biofuels. This is a timely energy issue that has no easy answer, requires collaboration among many different stakeholders, and provides a great learning experience for students. The issues raised also provide the opportunity for students to apply what they have learned throughout the unit about renewable and nonrenewable energy resources, transportation fuels, and sustainable energy solutions.

This PBA is incorporated into the last three lessons of *Fueling Our Future*. It is recommended that you first familiarize yourself with this overview, gather the materials listed on the previous page, and complete the preparation also listed on the previous page. Then follow the steps in Lessons 7, 8, and 9 to administer the PBA. The packet of student materials, *Sustainable Flight in the Pacific Northwest*, will be given to students during Lesson 7. Students will need to refer to the materials in this packet for Lessons 8 and 9.

Throughout these lessons, students will learn why there is a push to develop aviation biofuels, research potential feedstocks in the Pacific Northwest, take a position on what they think is the most sustainable biofuel mix, and negotiate with other stakeholders to create a policy for aviation biofuels in the region. Students will work both independently and collaboratively to answer the driving question: **What are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation?**

This PBA is context-specific in order to allow students to authentically assess the sustainability of developing certain feedstocks and learn about specific stakeholders in a particular region—the Pacific Northwest. You can adapt this PBA to focus on another region of the world or United States by changing the feedstocks and stakeholders that students analyze. It is also possible to use these lessons alone with slight modifications if you decide to opt out of the PBA.

Throughout the lessons, students will complete 3 products independently and 3 products in a small group. These products include:

Lesson	Product	Grading Method
Lesson 7	Class Research & Discussion	n/a
Lesson 8	*Product 1: The Life of a Fuel Poster* (Group) *Product 2: Supply Chain Evaluation* (Individual)	Rubric: 8 points Handout: 10 points
Lesson 9	*Product 3: Stakeholder Position Analysis* (Group) *Product 4: Council Member Negotiation* (Group) *Product 5: Negotiation Self-Assessment* (Individual)	Handout: 20 points Rubric: 12 points Handout: 9 points
After Lesson 9	*Product 6: Final Recommendation Paper* (Individual)	Rubric: 20 points

Name Date Class

Performance-based Assessment Packet

Sustainable Flight in the Pacific Northwest

Product 1 **Score__________**

Product 2 **Score__________**

Product 3 **Score__________**

Product 4 **Score__________**

Product 5 **Score__________**

Product 6 **Score__________**

Name Date Class

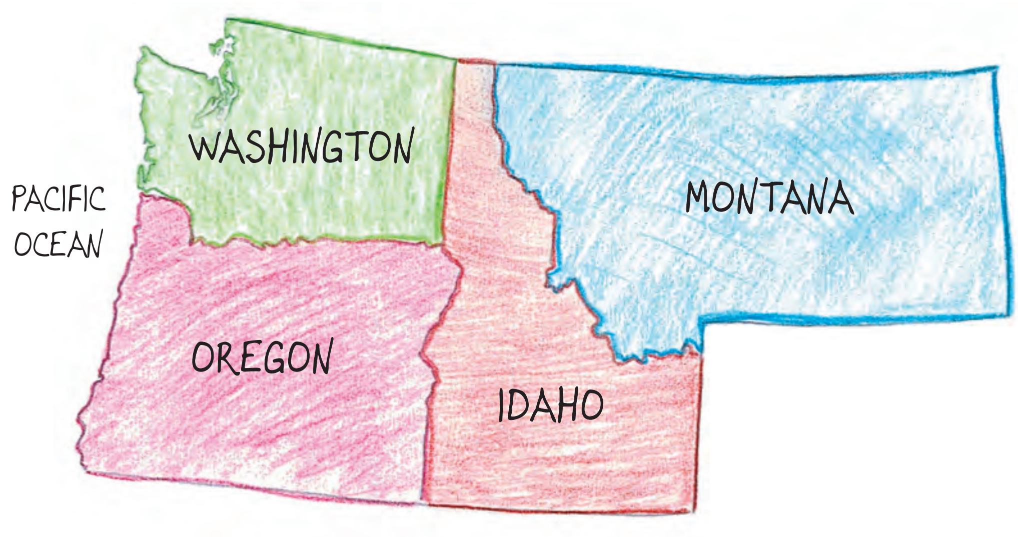
Scenario: Sustainable Flight in the Pacific Northwest

The federal government has mandated that an increasing amount of biofuel be mixed into jet fuel over the next few years in order to reduce the amount of crude oil used in the nation. The federal government has established regional councils to help identify the most sustainable biofuel feedstock(s) for different regions in the nation. You have been selected to be a part of the Pacific Northwest Regional Biofuel Council. This region includes Washington, Idaho, Montana, and Oregon. Over the next few days, you will:

- identify and understand the reasons for developing aviation biofuels,
- conduct research on different kinds of biofuels and consider their impacts on the environment,
- represent a specific stakeholder at a negotiation, identify other stakeholders' perspectives, and create a policy that identifies a sustainable fuel mix for the Pacific Northwest region,

so that you can answer the following question:

What are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation?



Name Date Class

Product 1: The Life of a Fuel Poster, page 1 (Group Activity)

Group Members: ______________________________

Feedstock: ______________________________

Directions: Follow the steps below to complete this product.

Part I. Research

A. As a group, decide whether to read the *Feedstock Fact Sheet* together or individually.

B. As you read, annotate or highlight the text to identify key information about your feedstock and its biofuel supply chain.

C. If desired, you can conduct additional research. Some websites that might be helpful are listed below.

- **Video:** *Energy 101|Biofuels*
  http://www.youtube.com/watch?v=-ck3FYVNl6s
  Watch this video, created by the U.S. Department of Energy, to get an overview of how biofuels can be made from biomass.
- **Interactive Mapping Tool:** *National Renewable Energy Laboratory: Biofuels Atlas*
  http://maps.nrel.gov/biomass
  Use the interactive mapping tool and to view the energy infrastructure and feedstock supplies that already exist in the Pacific Northwest.
- **Website:** *Biofuel.org.uk*
  http://biofuel.org.uk/
  Use this website to find general information about biomass and biofuels as well as information about specific feedstocks.

Name Date Class

Product 1: The Life of a Fuel Poster, page 2
(Group Activity)

Part II. Rough Draft

A. After your group has finished reading the *Feedstock Fact Sheet,* identify the main steps in the supply chain of your biofuel and discuss how you will represent each step with a drawing on your poster. Draw a rough draft below:

B. For each step of the above supply chain, discuss answers to the following questions:

1. What is needed for this step? (These are called inputs and might include natural resources, human-made resources, or people.)
2. What is produced during this step? (These are called outputs and might include waste products, co-products, or fuel.)
3. What are the possible environmental, economic, and social impacts of these inputs and outputs?
4. How could some of the possible negative impacts of your biofuel be mitigated, or lessened?

Name Date Class

Product 1: The Life of a Fuel Poster, page 3 (Group Activity)

Part III. Final Product

When your group is ready, draw a flow chart showing the supply chain—from feedstock to consumption—required to produce your biofuel and the major inputs and outputs of each step. Refer to the rubric below to make sure your poster is complete and of excellent quality.

Rubric for The Life of a Fuel Poster

	4	3	2	1
Content Knowledge and Skills	Demonstrates accurate understanding of the major ideas and concepts behind the supply chain of a specific biofuel	Demonstrates a general understanding of the major ideas and concepts behind the supply chain of a specific biofuel	Demonstrates a limited understanding of the major ideas and concepts behind the supply chain of a specific biofuel	Demonstrates minimal or no understanding of the major ideas and concepts behind the supply chain of a specific biofuel
Synthesis of Research	Demonstrates a clear skill to synthesize research and clearly present this information in the supply chain poster	Demonstrates general skill to synthesize research and mostly presents this information in the supply chain poster	Demonstrates limited skill to synthesize research and only somewhat presents this information in the supply chain poster	Demonstrates minimal or no skill to synthesize research and does not present this information in the supply chain poster

Name Date Class

Product 2: Suppy Chain Evaluation, page 1
(Individual Activity)

Directions: After you have participated in the Gallery Walk, reflect on what you have learned about biofuel supply chains by answering the following questions. Be sure your answers show critical thinking and evidence where necessary. Each question is worth 2 points.

1. Describe either a) the similarities and differences between the biofuels you learned about, or b) a pattern you observed among the different biofuel supply chains.

2. How did the suggestions provided by your classmates compare to your ideas about improving the sustainability of your supply chain?

3. Which biofuels, if any, seem better suited to the Pacific Northwest region? Why? (If none of the biofuels seemed suited to the Pacific Northwest region, then please explain why.)

Name Date Class

Product 2: Suppy Chain Evaluation, page 2
(Individual Activity)

4. What are some possible unintended or unforeseen consequences of developing a biofuel supply chain in the Pacific Northwest?

____

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5. Using what you have learned from this activity, describe the characteristics of a sustainable biofuel supply chain.

____

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____

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____

____

Name Date Class

Product 3: Stakeholder Position Analysis, page 1
(Group Activity)

Group Members: ______________________________

Stakeholder: ______________________________

Directions: Complete the *Stakeholder Position Analysis* below as a group. You should use the *Feedstock Fact Sheets* and *Stakeholder Profile* to complete this product and to help you prepare for the Pacific Northwest Regional Biofuel Council Meeting. This product is worth 20 points.

1. Based on your stakeholder's perspective and interests, summarize in 3 to 4 sentences who you represent. (2 points)

____

____

____

____

____

____

____

2. Based on your stakeholder's perspective, complete the following chart below. Use evidence from the feedstock handouts to explain your thinking. You may have to make inferences. (8 points)

	Pros	**Cons**
Algae		
Oilseed		
Solid Waste		
Woody Biomass		

Product 3: Stakeholder Position Analysis, page 2 (Group Activity)

3. Who are stakeholders that may have a different position from the stakeholder you represent? Why? (2 points)

4. Who are stakeholders that may share a similar position to the stakeholder you represent? Why? (2 points)

5. What are the most important interests of your stakeholder group? Which of the feedstocks you researched best serve these interests? (2 points)

Name Date Class

Product 3: Stakeholder Position Analysis, page 3
(Group Activity)

6. What might your stakeholder group be willing to compromise on? What might your stakeholder group not be willing to compromise on? (2 points)

7. Craft a policy that states the fuel mix you recommend and any other conditions you would like to include based on your stakeholder's position. You should be able to explain how your proposed policy is sustainable and not just beneficial to your stakeholder group. (2 points)

Name Date Class

Product 4: Council Member Negotiation
(Group Activity)

At the stakeholder meeting, your stakeholder group will need to negotiate with other groups in order to create a policy recommendation for a sustainable biofuel mix in the Pacific Northwest. Along with the Stakeholder Position Analysis you complete in preparation for the stakeholder meeting, your group participation in the meeting will also be assessed based on the following rubric. All students in a group are expected to speak up equally.

Rubric for Negotiation

	4	3	2	1
Collaboration	• Negotiates in ways that are respectful • Effectively communicates to move the conversation forward • Effectively engages with others to find common ground, discuss compromise, and/or seek consensus	• Tries to negotiate in ways that are respectful • Effectively communicates and sometimes moves the conversation forward • Makes an effort to find common ground, discuss compromise, and/or seek consensus	• Sometimes tries to negotiate in ways that are respectful • Attempts to communicate, but does not always move conversation forward • Makes some effort to find common ground, discuss compromise, or seek consensus	• Does not negotiate in ways that are respectful • Does not attempt to communicate or move conversation forward • Does not engage with others or attempt to find common ground, discuss, compromise, or seek consensus
Communication	• Consistently demonstrates active listening and speaks persuasively • Makes eye contact with those who are speaking and consistently uses body language that is welcoming and contributes to conversation (i.e. nodding head, sitting up straight) • Uses thoughtful and rigorous vocabulary and word choice	• Sometimes demonstrates active listening and makes clear arguments when speaking • Makes some eye contact with those who are speaking and often uses body language that is welcoming and contributes to conversation • Uses intentional vocabulary and word choice	• Occasionally demonstrates active listening and speaks • Makes eye contact with those who are speaking every so often and sometimes uses body language that is welcoming and contributes to conversation • Uses appropriate vocabulary and word choice	• Rarely demonstrates active listening or speaks • Rarely makes eye contact with those who are speaking and does not use body language that is welcoming or that contributes to conversation (i.e. slouches, rolls eyes) • Does not attempt to use appropriate vocabulary and word choice
Critical Thinking[3]	• Demonstrates thorough understanding of multiple perspectives on this issue • Asks and responds to higher level questions of other people to gain understanding • Shares and/or responds to a unique idea that elevates the conversation	• Demonstrates understanding of multiple perspectives on this issue • Asks and responds to questions of other people in order to gain understanding • Shares and/or responds to a unique idea	• Demonstrates awareness of, but limited understanding of, multiple perspectives on this issue • Asks or responds to questions of other people in order to gain understanding • Shares or responds to a unique idea	• Sticks closely to own perspective, and does not show awareness of other perspectives on this issue • Does not ask or respond to higher questions • Repeats information and ideas rather than sharing new ones

Name Date Class

Product 5: Negotiation Self-assessment, page 1 (Individual Activity)

At the stakeholder meeting, your stakeholder group negotiated with other groups in order to create a policy recommendation for a sustainable biofuel mix in the Pacific Northwest. All students in your group were expected to speak up equally. Take the time to do a self-assessment of your negotiation skills. Circle the number that most reflects your score under collaboration, communication, and critical thinking. Then, answer the questions.

Rubric for Negotiation

	4	3	2	1
Collaboration	• Negotiates in ways that are respectful • Effectively communicates to move the conversation forward • Effectively engages with others to find common ground, discuss compromise, and/or seek consensus	• Tries to negotiate in ways that are respectful • Effectively communicates and sometimes moves the conversation forward • Makes an effort to find common ground, discuss compromise, and/or seek consensus	• Sometimes tries to negotiation in ways that are respectful • Attempts to communicate, but does not always move conversation forward • Makes some effort to find common ground, discuss compromise, or seek consensus	• Does not negotiate in ways that are respectful • Does not attempt to communicate or move conversation forward • Does not engage with others or attempt to find common ground, discuss, compromise, or seek consensus
Communication	• Consistently demonstrates active listening and speaks persuasively • Makes eye contact with those who are speaking and consistently uses body language that is welcoming and contributes to conversation (i.e. nodding head, sitting up straight) • Uses thoughtful and rigorous vocabulary and word choice	• Sometimes demonstrates active listening and makes clear arguments when speaking • Makes some eye contact with those who are speaking and often uses body language that is welcoming and contributes to conversation • Uses intentional vocabulary and word choice	• Occasionally demonstrates active listening and speaks • Makes eye contact with those who are speaking every so often and sometimes uses body language that is welcoming and contributes to conversation • Uses appropriate vocabulary and word choice	• Rarely demonstrates active listening or speaks • Rarely makes eye contact with those who are speaking and does not use body language that is welcoming or that contributes to conversation (i.e. slouches, rolls eyes) • Does not attempt to use appropriate vocabulary and word choice
Critical Thinking[3]	• Demonstrates thorough understanding of multiple perspectives on this issue • Asks and responds to higher level questions of other people to gain understanding • Shares and/or responds to a unique idea that elevates the conversation	• Demonstrates understanding of multiple perspectives on this issue • Asks and responds to questions of other people in order to gain understanding • Shares and/or responds to a unique idea	• Demonstrates awareness of, but limited understanding of, multiple perspectives on this issue • Asks or responds to questions of other people in order to gain understanding • Shares or responds to a unique idea	• Sticks closely to own perspective, and does not show awareness of other perspectives on this issue • Does not ask or respond to higher questions • Repeats information and ideas rather than sharing new ones

Name Date Class

Product 5: Negotiation Self-assessment, page 2
(Individual Activity)

1. Based on the rubric, how would you rate your collaboration skills? Explain why you gave yourself the score you did. (3 points)

2. Based on the rubric, how would you rate your communication skills? Explain why you gave yourself the score you did. (3 points)

3. Based on the rubric, how would you rate your critical thinking skills? Explain why you gave yourself the score you did. (3 points)

Name Date Class

Product 6: Final Recommendation Paper, page 1
(Individual Activity)

In a group you have completed the *Stakeholder Position Analysis* and negotiated from the perspective of a given stakeholder. You will now write a final reflection paper that represents your personal stance and share what you believe to be the most sustainable fuel solution for the Pacific Northwest.

Part I. Review

Review the rubric and the five products you completed to prepare to write this paper.

Part II. Write

Write a 5-paragraph position paper that includes the following:

A. Overall recommendation: You should include a clear description of your personal recommendation for what you believe are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation.

B. Evidence: You should provide 3 specific reasons for your recommendation, supported by credible evidence. These reasons should reflect what you have learned throughout this unit and demonstrate how your recommendation will be environmentally, socially, and economically sustainable for the Pacific Northwest.

C. Bibliography: You should provide the sources used for this paper.

Name Date Class

Product 6: Final Recommendation Paper, page 2
(Individual Activity)

Rubric for Final Recommendation Paper[3]

	4	3	2	1
Recommendation	• States a thoughtful and clear personal recommendation for the most sustainable biofuels that can be produced in the Pacific Northwest	• States a clear personal recommendation for the most sustainable biofuels that can be produced in the Pacific Northwest	• States a somewhat clear personal recommendation for the most sustainable biofuels that can be produced in the Pacific Northwest	• States a vague, implausible, or inaccurate personal recommendation for the most sustainable biofuels that can be produced in the Pacific Northwest
Background	• Provides a thoughtful analysis of the different feedstocks considered for the Pacific Northwest and the pros and cons of each	• Provides an analysis of the different feedstocks considered for the Pacific Northwest and the pros and cons of each	• Provides information on the different feedstocks considered for the Pacific Northwest and some of their pros and cons	• Provides incomplete information on only 1 or 2 of the feedstocks considered for the Pacific Northwest and some of their pros and cons
Supporting Evidence	• Provides at least 3 credible reasons for the recommendation that are well supported by evidence	• Provides at least 2-3 credible reasons for the recommendation that are supported by evidence	• Provides only 1 reason for the recommendation that is supported by evidence	• Provides reasons for the recommendation that are supported only by personal opinions
Accuracy	• Has no inaccuracies	• Has a few minor inaccuracies that do not contradict or weaken the overall position	• Has several minor inaccuracies or 1 or more major inaccuracies that contradict or weaken the overall position	• Is largely inaccurate
Citations and Bibliography	• Makes explicit references within the paper to 3 or more credible sources that provide relevant information • Includes a bibliography	• Makes explicit references within the paper to 2 or more credible sources that provide relevant information • Includes a bibliography	• Makes explicit references within the paper to 1 credible source that provides relevant information • Includes a bibliography	• Makes no explicit references within the paper to credible sources that provide relevant information • Includes an incomplete bibliography or no bibliography

Lesson 7

The Sky's the Limit

Students are introduced to the context for this unit's PBA and its driving question, what are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation? Through class discussion and a series of stations featuring different multimedia resources, students learn about the aviation industry and its use of petroleum-based fuel. Students regroup after the stations to share their findings and identify 3 main arguments for reducing our use of petroleum.

Objectives

Students will:

- identify the relevance of aviation to their lives
- critically analyze information from different multimedia resources
- identify the motivations for countries to develop alternative aviation fuels

Inquiry/Critical Thinking Questions

- What are environmental, social, and economic impacts of aviation?
- How can identifying an author's point of view help one to critically assess information?
- Is the current aviation industry sustainable? If not, what kinds of changes could be made to address its sustainability?

Time Required

One 60-minute class

Key Concepts

- **aviation**—The flying or operation of aircraft.
- **biofuel**—Fuel made from biomass, used mostly for transportation.
- **carbon emissions**—Releases of carbon, often in the form of the gas carbon dioxide (CO_2), into the atmosphere. These emissions can amplify Earth's greenhouse effect, raising average temperatures on Earth.
- **energy independence**—The ability of a nation or region to produce energy that is equal to the amount of energy consumed.
- **jet fuel**—A kind of aviation fuel created to be used in an aircraft.
- **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

5.1 Decisions concerning the use of energy resources are made at many levels.

5.4 Energy decisions are influenced by economic factors.

5.5 Energy decisions are influenced by political factors.

5.6 Energy decisions are influenced by environmental factors.

5.7 Energy decisions are influenced by social factors.

7.1 Economic security is impacted by energy choices.

7.3 Environmental quality is impacted by energy choices.

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Materials/Preparation

Packet: *Sustainable Flight in the Pacific Northwest,* 1 per student

Handout: *The Sky's the Limit,* 1 per student

Set up 5 stations around the classroom. Each station will have a different resource that provides information on topics such as aviation, energy independence, and biofuels. If a station requires an article, then print enough articles for the size of your small groups.

Station 1

Article: *Your Biggest Carbon Sin May Be Air Travel*
http://www.nytimes.com/2013/01/27/sunday-review/the-biggest-carbon-sin-air-travel.html
This *New York Times* article by Elisabeth Rosenthal speaks about the impacts of air travel on the environment.

Station 2

Website: *Aviation/Benefits Beyond Borders*
aviationbenefitsbeyondborders.org/
This website looks at the environmental, social, and economic benefits of aviation.

Station 3

Audio clip: *Air Force and Navy Turn to Biofuels*
http://www.npr.org/2011/09/26/140702387/air-force-and-navy-turn-to-bio-fuels
This 4-minute *National Public Radio* story by Elizabeth Shogren speaks to the rationale behind the Air Force and Navy's decision to search for alternatives to petroleum.

Station 4

Article: *The Dark Side of Energy Independence*
www.nytimes.com/2013/04/28/opinion/sunday/the-dark-side-of-energy-independence.html
This *New York Times* article by Benjamin Alter and Edward Fishman examines one of the United States' energy goals—energy independence. It argues that independence could lead to instability in other countries, which will inevitably impact the United States.

Station 5

Online Quiz: *What You Don't Know About Flights and Fuel*
http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/flights-and-fuel-quiz/
National Geographic offers an 11-question quiz related to flights and fuel for students to find out what they know.


NASA

Activity

Introduction

1. Welcome students to class and share that today they will begin a multi-day project wherein they will use what they have learned and already know about energy and transportation fuels to investigate aviation biofuels.

2. Define **aviation** *(the flying or operation of aircraft)* and ask students if they can think of ways they might be impacted by flight without ever stepping onto a plane. *(Answers could include receiving mail, having family fly to visit, flying food from other locations, military defense, air pollution, etc.)*

3. Pass out the *Sustainable Flight in the Pacific Northwest* packet to each student.

4. Have students turn to the *Scenario* and read this as a class.

5. In Think-Pair-Share format, ask students to identify important words or phrases in the driving question that will guide or constrain their answers. Have students explain why/how these words will influence their answers. *(Answers may include words and phrases like Pacific Northwest, most sustainable, aviation, and produced.)*

6. Now turn the class's attention toward the first line of the *Scenario*.

7. Ask the class, why do you think the federal government would want to reduce the amount of crude oil used in the nation?

8. Once the class has had a chance to discuss this, explain that today students are going to explore this question. Before they do, however, have the class predict 3 reasons why the U.S. government would want to want to reduce the amount of crude oil used in the nation and share their prediction with a neighbor. If desired, record this on the board or on a poster paper to review after the activity.

Steps

1. Explain to students that they will be visiting different stations around the room to investigate the reasons behind developing aviation biofuels.

2. Pass out the handout *The Sky's the Limit* to each student.

3. Point out the 5 stations around the room. As students learn information at each station, either by reading an article, reviewing a website, listening to an audio recording, or taking a quiz, they will record relevant information on the handout.

4. Explain that one of the columns on the handout is called "Point of View." Invite students to discuss ways to determine an author's point of view.


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5. Divide the class into groups of 4-5 students.
6. Point each group toward a different station. Have students spend 10 minutes at the first station, giving them a 1-minute warning after 9 minutes.
7. Have groups rotate clockwise to the next station and repeat the process.
8. After students have completed the stations and finished the handout, bring them back together as a class.
9. Reflect on the stations and the handout with the following questions:
    - What are some of the most surprising things you learned?
    - What are some questions you have after this activity?
    - How did identifying the author's point of view impact the way you interpreted the information presented?
    - Why are countries shifting from using only petroleum-based fuel for aviation to using biofuels as well?
10. Return to the predictions the class made at the beginning of class and discuss whether they still think these are the 3 main reasons why the federal government wants to reduce the amount of crude oil used in the nation. If not, have the class revise these 3 reasons. Reasoning may include:
    - National security *(importing less oil could improve the security of our nation)*
    - Environmental Protection *(burning oil produces greenhouse gases which contribute to climate change)*
    - Economics *(oil prices can be unpredictable and expensive)*
    - Nonrenewable Resource *(oil is a finite resource)*
    - Secure, Consistent Supply of Fuel *(if bio-fuels are produced domestically then we may be able to have a more secure and consistent supply of fuel)*
11. Continue the class discussion using the questions below.

SGT. STEPHEN DECATUR, U.S. ARMY

Discussion Questions

1. How are you impacted by flight?
2. What are environmental, social, and economic impacts of aviation?
3. Do you think the country should change from using only petroleum-based aviation fuel to a blend of petroleum-based fuel and biofuel? Why or why not?
4. How do consumers play a role in the development of alternative aviation fuels?
5. Is the current aviation industry sustainable? If not, what kinds of changes could be made to address its sustainability?
6. After this activity, do you think you might have a particular bias with respect to transportation and fuel? How might this influence the way you interpret information about transportation and fuel?
7. What kinds of connections do you see between energy independence and sustainability?

History Extension

Have students research the history of the aviation industry. When did it begin? How has it grown throughout time? What changes have been made to meet the needs of a growing population?

Service Learning Idea

Have students work in small groups and choose a specific airline company. They can research a few questions about the airline:

- How many flights does the airline have per day?
- Is the airline considering shifting to alternative fuels in the near future?
- Does the airline have a carbon offset program?
- What kinds of changes are they planning to make based on population growth and the increased need for flight?

Students can then create a database compiling the information about these different airlines and share it with parents and classmates via a website, blog, etc.

Name Date Class

The Sky's the Limit, page 1

Directions: Use the materials provided at each station to complete the following chart.

Station	Facts and Statistics	Point of View	Comments/Questions
	What are important facts and statistics that relate to the development of aviation biofuels?	What point of view is presented in this station? Do you agree or disagree with this point of view?	What questions or comments do you have about the ideas presented at this station?
1. Article: *Your Biggest Carbon Sin May Be Air Travel*			
2. Website: *Aviation/Benefits Beyond Borders*			
3. Audio clip: *Air Force and Navy Turn to Biofuels*			

Name Date Class

The Sky's the Limit, page 2

Station	Facts and Statistics	Point of View	Comments/Questions
	What are important facts and statistics that relate to the development of aviation biofuels?	What point of view is presented in this station? Do you agree or disagree with this point of view?	What questions or comments do you have about the ideas presented at this station?
4. Article: *The Dark Side of Energy Independence*			
5. Online Quiz: *What You Don't Know About Flights and Fuel* Record your answers to the quiz here: 1. _______ 7. _______ 2. _______ 8. _______ 3. _______ 9. _______ 4. _______ 10. _______ 5. _______ 11. _______ 6. _______			

Lesson 8

The Life of a Fuel

On Day 1, the class learns about the typical supply chain of a fuel. Small groups then research and create a poster to show the supply chain of a biofuel derived from a particular feedstock. On Day 2, students participate in a gallery walk to learn about the different ways to improve the sustainability of biofuels. Lesson 8 is a continuation of this unit's PBA.

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Objectives

Students will:

- identify the steps involved in the production and use of transportation fuels
- research a specific type of feedstock that could be used to produce aviation biofuel and create a poster to show its supply chain
- suggest how the supply chain of a particular fuel could be made more sustainable

Inquiry/Critical Thinking Questions

- What steps are needed to produce transportation fuels?
- How does the production of a biofuel impact the environment?
- What are the pros and cons of different biofuels?
- Does renewable imply sustainable?

Time Required

Two 60-minute classes

Key Concepts

- **biofuel**—Fuel made from biomass, used mostly for transportation.
- **co-product**—A useful product that is made in a step required for the manufacture another product. For example, a co-product produced during the manufacturing of corn-based ethanol is feed for livestock.
- **consumption**—The process of using natural resources, materials, or finished products to satisfy human wants and needs.
- **conversion**—In the context of biofuels, the process of changing feedstock into fuel.
- **distribution**—The transport and delivery of a product or good from its point of production to consumers.
- **extraction**—The process of obtaining natural resources from the land or the oceans.
- **feedstock**—The raw material used in manufacturing or processing. In the context of biofuels, feedstock refers to the renewable organic matter that is converted into fuel.
- **infrastructure**—The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communication systems, roads, water, power lines, and public institutions such as schools, post offices, and libraries.
- **supply chain**—The steps, people, and businesses involved in the entire life of a product or good from the extraction of natural resources to the waste products created by customer consumption.
- **transportation**—The carrying of people or goods from one place to another.

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4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.2 Human use of energy is subject to limits and constraints.

4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight.

4.4 Humans transport energy from place to place.

4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.

5.2 Energy infrastructure has inertia.

7.3 Environmental quality is impacted by energy choices.

Materials/Preparation

Optional Overhead: *Example: Corn-based Ethanol Supply Chain*

Refer to the PBA Packet for:

Scenario: Sustainable Flight in the Pacific Northwest;

Product 1: The Life of a Fuel Poster;

Product 2: Supply Chain Evaluation

Handout: *Feedstock Fact Sheets*, 1 per student for their assigned feedstock

Poster paper and markers

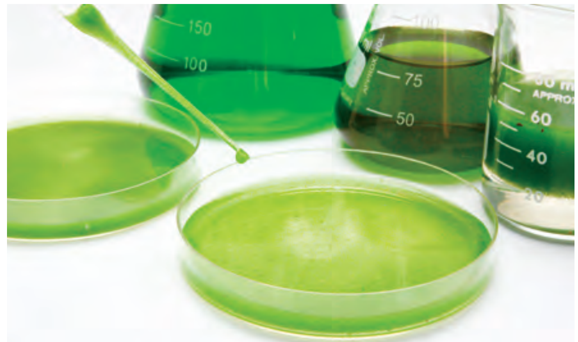
Optional: Internet access for student research on Day 1.

Overhead: *Breaking News!*

Post-it notes

Optional: Internet access and projector on Day 2 to show students the following activity:

- **Website:** *American Farmland Trust* http://www.farmland.org/Flash/appleEarth.html



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Activity—Day 1

Introduction

1. Write the phrase "well-to-wheel" on the board and tell students that this phrase is used to describe the supply chain of petroleum-based fuel. Inform students that supply chain refers to all the steps involved in the entire life of a product.
2. In Think-Pair-Share format, ask students to discuss what "well" and "wheel" refer to and what steps might occur between the well and wheel.
3. Once students have shared, draw the flow chart at the bottom of the page on the board.
4. As a class, discuss each of the terms in the flow chart using petroleum as an example. *(For example: scientists often use rock samples to locate underground oil, oil is pumped to Earth's surface, oil is shipped to a refinery or storage until oil is needed for refining, oil is converted into gasoline as well as many other co-products like chemicals and plastics, gasoline is distributed to gas stations or to storage until a later date, gasoline is pumped into a car and burned by the engine.)*
5. Now use the flow chart to outline the supply chain for one specific biofuel, corn-based ethanol. Consider writing this on a poster so you can save it for Day 2, Step 1.
6. In Think-Pair-Share format, have students come up with a phrase like well-to-wheel that better describes biofuels.
7. Explain that scientists often use the entire supply chain of a fuel to evaluate its sustainability. Ask students why evaluating the entire life of a fuel rather than just one step might help them better evaluate the sustainability of the fuel.
8. Use the overhead *Example: Corn-based Ethanol Supply Chain* to show students how the inputs (the natural or human-made resources required for a step) and outputs (what is produced at each step such as waste products or co-products) of a particular step in a supply chain can be captured on this flow chart.
9. Have the class identify steps in the corn-based ethanol supply chain where carbon dioxide is absorbed and where carbon dioxide is released.
10. Have students brainstorm the steps in the petroleum supply chain that absorb carbon dioxide and release carbon dioxide. *(Be sure the class observes that the main difference between biomass feedstocks and petroleum feedstocks is that the biomass feedstocks absorb carbon dioxide.)*

The Supply Chain of a Fuel

Feedstock → Extraction → Transportation → Conversion → Distribution → Consumption

↓ (from Conversion)

Co-product

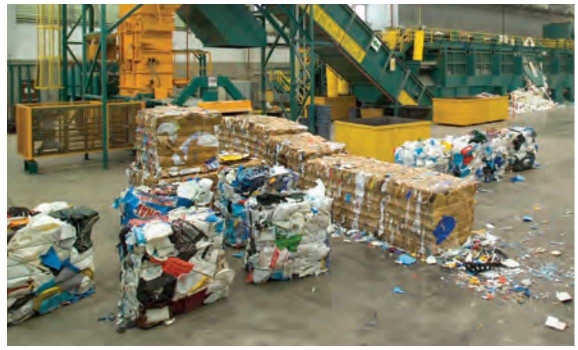

JUSTIN HOUGHAM

Option: Use one of the following videos to review the carbon cycle and the unique impact that fossil fuels have on the natural balance of this cycle.

- *The Hydrologic and Carbon Cycles: Always Recycle! – Crash Course Ecology#8*
  http://www.youtube.com/watch?v=2D7hZpIYlCA
  This video provides a fun, fast-paced explanation of the carbon and hydrologic cycles. To skip ahead to the carbon cycle, press play 5 minutes into the video. The carbon cycle segment is 5 minutes long.
- *The Carbon Cycle*
  http://epa.gov/climatestudents/basics/today/carbon-dioxide.html
  This 4-minute animated video is housed on the U.S. EPA's *A Student's Guide to Global Climate Change* website. It shows how humans are adding more carbon to the atmosphere faster than it is removed.

Steps

1. Explain to students that today they will begin to explore the driving question of the performance-based assessment. Have students turn to the *Scenario* handout in their packets.
2. Explain that small groups will conduct research on the supply chain of a particular biofuel to assess its sustainability in the Pacific Northwest. They will then create *Product 1: The Life of a Fuel Poster.*
3. Refer students to *Product 1: The Life of a Fuel Poster* in their packet and discuss the guidelines for completing this product.
4. Divide the class into groups of 3-4 students and assign each group 1 of the 4 feedstocks listed below. Depending on your class size, you may have more than one group researching the same topic.
   - algae
   - oilseed (camelina)
   - solid waste
   - woody biomass
5. Give each group the following materials:
   - **Handout:** *Feedstock Fact Sheet* for their assigned feedstock, 1 per student
   - **Poster paper and markers**
   - **Option:** Internet access for further research
6. Allow groups the rest of the class for research and product creation. Check in with each group periodically to evaluate the accuracy of their work and provide guidance as needed.



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Activity—Day 2

Introduction

1. Display the overhead *Breaking News!* (or use newspaper clippings of your own) and ask for volunteers to read them.
2. Use the following questions to guide a class discussion on the controversy associated with some biofuels:
   - What do these headlines suggest about using corn to make ethanol, a type of transportation fuel?
   - What questions do these headlines raise for you about corn-based ethanol?
   - How might using corn for fuel drive up food prices?
   - What are some questions you could ask about a particular feedstock or biofuel in order to determine whether or not it is sustainable?

   Option: Show students *The Apple As Planet Earth* video or consider using a real apple to demonstrate how much of the planet is available for growing crops and compare to student guesses.
3. Share with students that biofuels are put into different categories based on the type of biomass and the conversion technologies used. Advanced biofuels are also sometimes categorized as second- or third-generation biofuels.
   - First-generation biofuels are made from food crops. Examples include ethanol made from corn, wheat, and sugarcane.[1]
   - Advanced biofuels are made from non-food crops or unused food parts. Examples include waste vegetable oil, grasses, algae, and seed crops. These feedstocks can require different technology to convert them to fuel.[2]
4. In Think-Pair-Share format, have students identify the generation of the biofuel they researched and compare it to corn-based ethanol.

Steps

1. Review with students the general steps of the supply chain for corn-based ethanol. If you drew this supply chain on a poster in Day 1 then display it now.

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2. Ask students to discuss the following:
   - Can you see opportunities to improve the sustainability or lessen any negative environmental impacts of producing corn-based ethanol? *(Possible answers include: Corn could be grown without fertilizers, which are made from natural gas and can contaminate local water supply. If the fuel was produced at the farm, then less fuel would be used and less pollution produced during transport of corn to the refinery. People could carpool more often to school so that less fuel is used and fewer emissions are produced.)*
3. Explain that today students will participate in a gallery walk to review the posters created by each group. This will give students an opportunity to learn about all 4 biofuels, which they will need to know in order to answer the driving question. As they view posters, groups will evaluate each biofuel supply chain and make suggestions for how to improve its sustainability or lessen any negative environmental impacts.
4. Have students gather in groups around their posters and give each group a set of post-it notes.
5. Share with the class the following instructions:
   - When the bell rings (or you are otherwise instructed by the teacher), move in a clockwise direction to the next poster.
   - Examine the poster and discuss possible ways to improve the sustainability of the supply chain of this particular fuel.
   - Choose 1 idea to write down on a post-it and stick it on the poster. You may not repeat a suggestion that has already been mentioned by another group.
   - When the bell rings (or you are otherwise instructed by the teacher), move in a clockwise direction to the next poster and repeat these steps. A different group member should write the group idea down on a post-it each time.
6. Give groups about 3 minutes at each poster to examine the supply chain and make their suggestion.
7. When finished, have students come back to their desks to reflect on the activity.
8. Refer students to the handout *Product 2: Supply Chain Evaluation* in their *Sustainable Flight in the Pacific Northwest* packet and discuss the guidelines for its completion. Give students time to complete this product.
9. Use the following questions to guide a class discussion.

LAURA SKELTON

Discussion Questions

1. Which type of fuel would you want to be produced in your community? Why?
2. Biomass is considered a renewable resource. What are some factors that might determine whether or not the use of biomass as a fuel source is *sustainable*?
3. What is the significance of co-products in the supply chain of a fuel?
4. How might existing infrastructure such as oil refineries, roads, rail, and jet engines help and hinder the development of biofuels?
5. How could the geography of a region impact whether or not a feedstock is sustainable? Can you think of a feedstock that would probably be unsustainable in the Pacific Northwest but might be sustainable elsewhere?
6. What are the hidden impacts associated with fuels that most people do not know about? Do you think that being aware of these hidden impacts would influence the way that people use fuel?
7. How do our choices about what to research and develop impact the alternative fuel options available?
8. What are some risks posed by biofuel production? How would you determine if the benefits outweigh the risks, or vice versa?

Science and Engineering Extension

Have students design a model to represent the impact of burning fossil fuels on the carbon cycle. Then facilitate a peer review of the models and have students make revisions to their original models or submit a proposal describing how they could revise the model. The following resources may be helpful for student research:

- **Animation:** *Carbon Cycle Animation*
  http://elearn.wvu.edu/faculty/demo/Module_2/carbon_cycle_animation.html
  Viewers can click on different contributors of the carbon cycle to learn more about the processes that absorb and release carbon.
- **Report:** *Carbon 101: Understanding the Carbon Cycle and the Forest Carbon Debate*
  http://www.dovetailinc.org/reportsview/2012/responsible-materials/pjim-bowyerp/carbon-101
  This Dovetail Partner Report by Jim Bowyer provides a detailed overview of the carbon cycle and the difference between fossil fuels and biomass with respect to carbon.

LAURA SKELTON

Service Learning Idea

Have students learn about ecosystem services and then perform an ecosystem audit, either in the school community or the local community, to determine the direct benefits their community gains from local ecosystems. To begin their research, students might visit Facing the Future's website (www.facingthefuture.org) and click on the *Issues & Solutions* tab to learn more about *Biodiversity & Ecosystems.*

Additional Resources

- **Website:** *International Energy Agency*
  http://www.iea.org/
  This website has information and statistics about various energy issues including biofuels and bioenergy. This could be a resource for teachers and students to gather more information about energy.

- **Video:** *Energy 101|Biofuels*
  http://www.youtube.com/watch?v=-ck-3FYVNl6s
  This video, created by the U.S. Department of Energy, provides an overview of how biofuels can be made from biomass.

- **Interactive Mapping Tool:** *National Renewable Energy Laboratory: Biofuels Atlas*
  http://maps.nrel.gov/biomass
  This interactive mapping tool can be used to view the energy infrastructure and feedstock supplies that already exist in the Pacific Northwest.

- **Website:** *Biofuel.org.uk*
  http://biofuel.org.uk/
  This website provides general information about biomass and biofuels as well as information about specific feedstocks.

- **Field-based Lesson:** *The Value of a Tree*
  http://adventurelearningat.com/for-teachers/
  This hands-on lesson has students calculate and compare the amount of jet fuel that could be produced by a tree vs. the amount of carbon that could be sequestered by the tree. This lesson can foster a discussion about the value that we place on trees.

- **Article:** *Fuel From Waste, Poised at a Milestone*
  http://www.nytimes.com/2012/11/14/business/energy-environment/alternative-fuels-long-delayed-promise-might-be-near-fruition.html?_r=0%20&adxnnl=1&pagewanted=all&adxnnlx=1376078540-NUnIigdw1v-re2ACsfbvrKw
  This *New York Times* article by Matthew L. Wald provides an effective overview of the history and challenges of creating biofuels from cellulose at the commercial scale. It also provide a nice introduction to the importance of economics in this endeavor. For a follow-up article, see Wald's July 31, 2013 article called *Milestone Claimed in Creating Fuel From Waste.*

Example: Corn-based Ethanol Supply Chain

This table shows how one might depict the supply chain of corn-based ethanol. Some possible inputs and outputs are listed above and below each step, respectively.

CO_2, H_2O, sunlight energy, fertilizers, pesticides, gas for machinery, people to perform work ↓	Fuel energy for vehicles transporting corn, people to perform work ↓	Fuel energy for machinery, electrical energy for facilities, water, people to run the machines ↓	Fuel energy for vehicles transporting the fuel, truck drivers ↓	Fuel energy for vehicles driving to gas stations, fuel and electricity to operate gas stations, drivers ↓	O_2, fuel energy, drivers ↓
Corn is grown and harvested →	**Corn is taken from farm to refinery** →	**Machines and chemicals change corn into fuel** →	**Fuel is taken to retail locations** →	**Customers buy fuel** →	**Fuel is burned in cars, trucks, or planes** →
↓ O_2 from living corn, CO_2, chemicals from fertilizers and pesticides, heat, CO_2	↓ CO_2, emissions from vehicles burning fuel, heat	**↓** **Co-products (like feed for livestock)**, CO_2, emissions from machinery burning fuel or using electricity, heat	↓ CO_2, emissions from vehicles burning fuel, heat	↓ CO_2, emissions from vehicles burning fuel, heat	↓ CO_2, emissions from vehicles burning fuel, heat

Breaking News!

As Ethanol Takes Its First Steps, Congress Proposes a Giant Leap[3]

(*New York Times* 2007)

Bioenergy: Fuelling the food crisis?[4]

(*BBC News* 2008)

Is Ethanol a Solution, or a Problem?[5]

(*New York Times* 2011)

Corn Prices Rise Worldwide Due to U.S. Ethanol Policy, FAO Says[6]

(*Bloomberg* 2012)

Oil, biofuel companies evolve into uneasy 'frenemies'[7]

(*Chicago Tribune* 2012)

Feedstock Fact Sheet: Algae[8]

Algae are organisms that live in water and range in size from single-celled to complex multicellular forms like kelp. Algae can survive in a wide variety of habitats and have been found in salt water, freshwater, deserts, hot springs, and ice.[9] Microalgae, or single-celled algae, are the form of most interest to people in the biofuels industry. Over the years, researchers have found that about 10-50% of algae is oil that can be extracted and used to produce biofuels.

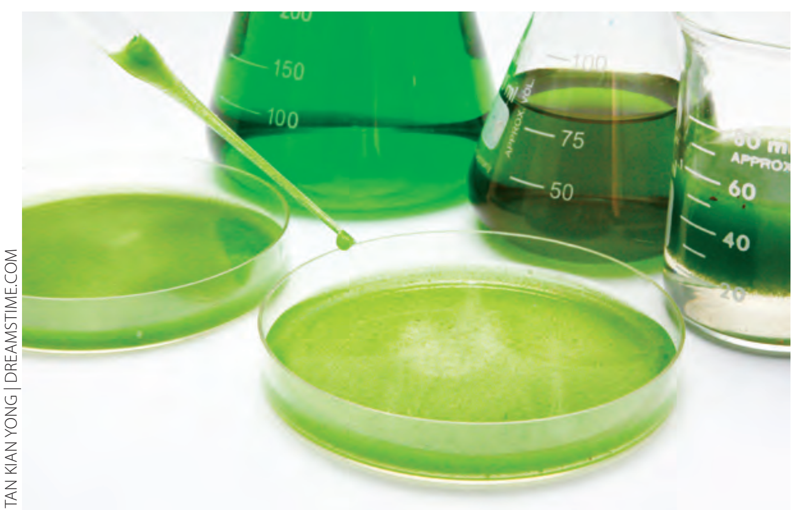
Feedstock

Algae need energy, nutrients, and water in order to grow. Photosynthetic algae use the sun as their energy source, while heterotrophic (organisms that cannot make their own food) algae use a carbon-rich chemical energy source to grow just as animals do. Researchers in the Pacific Northwest have suggested using both types of algae so that biomass can be grown year round—even when there is less sun. Both types of algae need heat and large amounts of carbon dioxide (CO_2) and nutrients like nitrogen and phosphorous. Because of this, algae cultivation would ideally be situated near power stations, cement plants, wastewater plants, dairy farms, pulp or paper plants, or other industrial areas that produce CO_2, heat, and nutrients. This has the added benefit of preventing the release of some of these waste products into the environment, especially CO_2, that would otherwise contribute to climate change.

Algae can be grown in open ponds or in closed bioreactors. Both methods require land and water. One study showed that 530,000 gallons of water were needed to fill a 20-centimeter deep 2.5 acre pond. Open ponds are exposed to changes in temperature and humidity and can be contaminated by outside algae species. Growing algae in a bioreactor instead of an open pond is generally more water efficient, but bioreactors are more expensive than open pond systems. On the positive side, algae doesn't need freshwater to grow; it can grow in wastewater or salt water. Growing algae also requires less land than other energy crops and it can often be grown on land not suited for agriculture. This means that freshwater and arable land can be saved for food crops.

Collection and Extraction

Algae grow quickly and can be harvested every day or every week. Because microalgae are so small, they stay suspended in their water source and must be filtered from the water and concentrated before the oil can be removed from algal cells. This step, known as drying or dewatering, takes a large amount of energy.[10]



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Feedstock Fact Sheet: Algae *continued*

Conversion and Co-products

After the algae are removed and concentrated, three components are extracted from them: oil, carbohydrates, and proteins. The oil can then be refined into biofuels like jet fuel using already existing petroleum refineries. Carbohydrates and proteins can be converted into and sold as co-products such as animal feed, chemicals, and food. Some researchers also suggest converting the carbohydrates into fuel using a different processing method. These conversion processes require energy, chemicals, and equipment. If algae-based biofuels are to be commercially successful on a large scale, more research is needed to find ways to reduce the amount of energy needed for extraction and conversion processes.

Distribution and Consumption

It is likely that transporting biofuels to airports would be done using the same infrastructure that is used for fossil fuel transport. The Pacific Northwest has five main oil refineries in Washington State and petroleum products are transported via pipelines, barges, and trucks. Jet fuel is heavier than other fuels and is best shipped via trucks and barges. These transportation networks take refined fuels to storage facilities near airports or fuel terminals. This is where biofuels would be blended with petroleum-based jet fuel. Blended jet fuel would then be sent to airports using existing distribution systems.

Sustainability Factors: Algae	
Greenhouse Gas Emissions (GHG)	The amount of GHG produced in the algae-to-fuel supply chain is still unknown and depends on the processes used to convert algae and the fuels used to run machinery needed to cultivate and harvest algae. Studies have suggested that the production of biojet fuel from algae can create anywhere from one-fifth to twice the amount of GHG of petroleum-based jet fuel.
Food Security	Algae cultivation does not need land that could be used for food crops and its co-products can be used for animal feed.
Conservation	Large-scale cultivation of algae on sensitive lands could decrease the biodiversity of the area and harm ecosystems. If genetically modified algae are used, there is a risk that they might escape into surrounding ecosystems and become invasive species. Producers would have to comply with laws on genetically modified organisms.
Soil	Chemicals leaking into soil could be a concern if chemicals are used during the conversion process.
Water	It is possible to grow algae without freshwater, so this feedstock may not compete with food production for freshwater resources. Algae can be grown in wastewater or salt water and can in fact help clean these waters. However, growing algae requires a very large amount of water and after algae have been harvested the water might need to be treated to remove chemicals, fertilizers, salts, or other pollutants.
Air	Algae cultivation presents few air quality concerns.
Other Concerns	Additional research is needed to explore how to effectively use algae to produce fuel. The amount that could be produced in the Pacific Northwest and the cost of production are still unknown. Toxic chemicals used in conversion have significant impacts and are expensive. However, researchers are exploring more natural alternative methods.

Feedstock Fact Sheet: Oilseed (Camelina)[11]

As the name suggests, oilseeds are plants that produce seeds that contain lots of oil. Soybeans, sunflowers, canola, cotton, and peanuts are common types of oilseed that produce edible oils.[12] While many oilseeds thrive in the Midwest prairies, not all thrive in the Pacific Northwest. One oilseed that can grow in the Pacific Northwest is *Camelina sativa.* The oil content of camelina seeds ranges from 29-42%, making it a promising feedstock for biofuels.

Feedstock

Like other plants, oilseed crops use sunlight, carbon dioxide (CO_2), and water in the process of photosynthesis to produce food. In this process, they release oxygen to the atmosphere. Camelina is a hardy plant that can grow on lands unsuitable for food and matures in a short time (85-100 days). It can tolerate low and high temperatures, and can be planted in fall, winter, and spring.

In drier areas of the Pacific Northwest, wheat is grown in the winter and fields are left fallow during the summer. Fallow fields are often sprayed with herbicides or tilled using farming equipment, and these uncovered soils may suffer soil erosion from wind and loss of moisture. Cover crops grown during the summer help retain soil moisture and nutrients, prevent soil erosion, break up pest breeding cycles, and maintain a biological diversity that supports healthy soils. Oilseeds like camelina are a possible cover crop that could improve the agricultural sustainability of the area while producing a new biofuel feedstock.

There are risks and costs to farmers who grow oilseed crops in rotation with wheat. Summer cover crops use inputs like fertilizers and chemicals. During particularly dry periods, these crops may absorb more moisture from the soil than if the fields had been left fallow, possibly reducing the amount of wheat produced the following winter.

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Pacific Northwest farmers who grow camelina face additional uncertainty. While camelina has been cultivated for years in Eastern Europe, it is relatively new to the United States and how productive and effective this crop could be in the Pacific Northwest is still unknown. Farmers may not be willing to plant camelina unless it is shown to be agriculturally successful and economically profitable.

Collection and Extraction

Oilseed crops can be harvested, transported, and stored using the same machinery and infrastructure used for wheat. Their seeds are fairly stable and do not break easily, which helps preserve them during the collection process. Once collected and stored, seeds will be crushed to extract the oil when needed. The Pacific Northwest has some small crushing facilities, but in order to produce oilseed-based biofuel on a large enough scale to make it economically viable, facilities for processing oilseed crops would need to be expanded.

Feedstock Fact Sheet: Oilseed (Camelina) *continued*

Conversion and Co-products

The process to convert oilseeds into biojet fuel requires hot water and energy. Apart from its oil content, around 70% of oilseed's volume by weight is meal. Converting this meal into a secondary product that can be sold is necessary to make this biofuel feedstock profitable. The biggest opportunity to use oilseed meal is in animal feed, but there are factors that may limit this use. Currently only a small portion of *Camelina sativa* meal can be added to animal feed because it contains a chemical that can interfere with an animal's metabolism and reproduction. Other co-products such as fuel pellets or soil enhancements could be made from the meal.

Distribution and Consumption

It is likely that transporting biofuels to airports would be done using the same infrastructure that is used for fossil fuel transport. The Pacific Northwest has five main oil refineries in Washington State and petroleum products are transported via pipelines, barges, and trucks. Jet fuel is heavier than other fuels and is best shipped via trucks and barges. These transportation networks take refined fuels to storage facilities near airports or fuel terminals. This is where biofuels would be blended with petroleum-based jet fuel. Blended jet fuel would then be sent to airports using existing distribution systems.

Sustainability Factors: Oilseeds	
Greenhouse Gas Emissions (GHG)	One study suggested that compared to petroleum-based fuels, an oilseed-to-fuel supply chain could reduce GHG by 80-85%. While this study included uses of nitrogen fertilizer for oilseed crops, it did not consider direct or indirect land use changes that might occur if oilseeds are not grown on fallow fields.
Food Security	It is still unknown how growing crops like camelina in rotation with wheat may impact the amount of wheat produced in the same field. Using camelina meal for animal feed could also impact demand for high protein feed bought from the Midwest or Canada.
Conservation	In addition to agricultural land where wheat is currently grown, oilseed crops can be planted on other lands that are at risk of erosion to support conservation aims. However, areas that are critical for biodiversity or water health should be avoided.
Soil	Oilseed cover crops have been shown to reduce soil erosion and add organic matter to the soil, increasing soil fertility in the long run. Although fertilizers and herbicides may be used to grow cover crops, they are usually also used on fallow fields.
Water	While fallow fields lose moisture to evaporation, oilseeds capture moisture and transfer it to the soil. However, oilseed cover crops do draw on the soil's moisture content, leaving less water available to fall wheat crops and possibly impacting wheat yields.
Air	Growing camelina in rotation with wheat reduces soil erosion in agricultural areas. As a result, less small particulate matter is released into the air, improving local air quality.
Other Concerns	Agricultural yields are still uncertain due to climate and rainfall variation, meaning the supply of this feedstock may not always be predictable. There is also a need for additional research to show economic viability of camelina and to identify varieties that could be better suited to animal feed or other co-products.

Feedstock Fact Sheet: Solid Waste[13]

People and industries produce a lot of waste, or garbage. Municipal solid waste refers to the waste that comes from homes, schools, hospitals, and businesses. This includes packaging, yard clippings, clothing, old furniture, bottles, and food scraps.[14] Industrial solid waste refers to the waste that comes from industry and commercial operations such as food processing plants.[15]

Feedstock

Even when cities recycle and compost, a large amount of organic waste ends up in landfills. Many people in the biofuels industry see organic waste as a potential feedstock for biofuel. Paper, packaging, wood waste from construction sites, and yard waste all contain chemical energy that could be converted into fuel. Using solid waste as a feedstock could divert some waste from landfills that are quickly filling up and are often quite costly. In the state of Washington alone, over 2 million tons of organic solid waste ends up in landfills—even after waste has been diverted to recycling or composting facilities.

Collection and Extraction

Unlike with other feedstocks, there are already systems and infrastructure in place for the collection, transport, and storage of solid waste. Conversion systems to create solid waste-based biofuels could be set up near this infrastructure. A significant amount of waste is hauled to landfills by train. If organic waste was instead converted into biofuels in facilities near collection networks, the amount of transportation fuel needed and related greenhouse gas emissions could be reduced. One challenge is that current policy requires that waste streams going to recycling and composting do not decrease because of the interest in producing biofuel from waste.

Conversion and Co-products

There are many different processes used to convert organic waste to jet fuel. One of the biggest challenges is filtering out waste that contains pollutants or toxins. Communities where conversion facilities are located are often concerned

Feedstock Fact Sheet: Solid Waste *continued*

about possible contamination of air, water, and soil by these pollutants.

The technology exists to convert waste into ethanol and studies show that this process is economically viable. Converting waste into aviation fuel, which is more energy dense, would be more expensive. There are a variety of ways to turn waste into fuel and most would require heat, chemicals or microorganisms, and acids or enzymes. Large, bulky waste may require technology to make it smaller before conversion. Co-products generated from converting waste to fuel could include chemicals, bio-oils, biochar (which can be used to enhance soils) and syngas (which can be burned as a fuel). It is also possible to make insulation, roof tiles, and road-making materials from the byproducts of the conversion process.

Distribution and Consumption

It is likely that transporting biofuels to airports would be done using the same infrastructure that is used for fossil fuel transport. The Pacific Northwest has five main oil refineries in Washington State and petroleum products are transported via pipelines, barges, and trucks. Jet fuel is heavier than other fuels and is best shipped via trucks and barges. These transportation networks take refined fuels to storage facilities near airports or fuel terminals. This is where biofuels would be blended with petroleum-based jet fuel. Blended fuels would then be sent to airports using existing distribution systems.

Sustainability Factors: Solid Waste	
Greenhouse Gas Emissions (GHG)	One study comparing gasoline and ethanol produced from waste found that ethanol reduced GHG by 81%. This study did not include emissions reductions due to shipping less waste to landfills. Of course, jet fuel is different than ethanol, but this provides some point of comparison.
Food Security	Using solid waste for fuel presents few concerns about food security.
Conservation	Due to the potential for contamination by pollutants, fuel plants should be located in areas where they will not pose a risk to critical species, ecosystems, or water systems.
Soil	Some leakage may occur from solid waste facilities and landfills into surrounding soils and water. Surface and groundwater quality around these facilities should be monitored and maintained. Diverting some solid waste from landfills to biofuel production could potentially reduce leakage from landfills into soils.
Water	Some leakage may occur from solid waste facilities and landfills into surrounding soils and water. Surface and groundwater quality around these facilities should be monitored and maintained.
Air	Community members are often concerned about the emission of toxins during the conversion of waste to fuel. Biofuel plants should follow all laws regulating air pollution.
Other Concerns	Fuel plants must take steps to prevent the release of toxins and hazardous materials. There also exists some competition and debate about the best use of waste streams especially when considered alongside recycling, composting, and electricity production.

Feedstock Fact Sheet: Woody Biomass[16]

Woody biomass is plant material that comes from trees and shrubs such as roots, bark, leaves, branches, trunks, and vines.[17] Just like other plants, trees and shrubs use sunlight, water, and carbon dioxide (CO_2) during the process of photosynthesis to make sugars and complex carbohydrates like cellulose and starch. These carbohydrates have chemical energy that, when burned, release CO_2 and heat energy. Researchers are currently investigating ways to convert the complex molecule cellulose found in woody biomass into aviation fuel and other co-products. Woody biomass could be a promising feedstock for the Pacific Northwest as almost half the region is covered by forests.[18]

Feedstock

In order for woody biomass to be a practical option as a feedstock, there must be a consistent and adequate supply available to biofuel producers. This means it is important to find a source of biomass that does not have a lot of competition with other markets. For instance, there are many sawmills in the Pacific Northwest that create wood waste from processing timber. While this biomass could be turned into fuel, it is currently used to generate electricity or provide feedstock for pulp and paper plants.

Another source of woody biomass is forest residuals. Forest residuals, also known as logging slash, are generally not used by other markets. Forest residuals like tree branches and bark are left behind when logs are cut and hauled away. They are usually left on site to decompose or are burned, returning nutrients to forest soils. Some stakeholders feel that removing forest residuals and using them for fuel would not be healthy for forest ecosystems.

Collection and Extraction

One major reason why forest residuals are currently underused is that they are bulky and spread out in forests, making this source of biomass expensive to collect and transport to processing plants. There are a couple of ways to make the collection process less expensive. One way is to collect forest residuals from the places where the logging industry has left them after cutting logs. Another is to put bulky woody biomass into a chipper before transporting it so that a more concentrated amount of biomass can fit onto each truck. Limiting the time and distance trucks must drive from a wood source to a refinery is another way to reduce costs. Researchers suggest a one-hour drive or a 50-mile driving radius as a reasonable limit. Along with trucks to transport forest residuals, extraction and collection requires machines such as loaders, chippers, and conveyors—all of which require fuel.

JUSTIN HOUGHAM

Feedstock Fact Sheet: Woody Biomass *continued*

Conversion and Co-products

To make fuel from woody biomass, it is first broken down into its main chemical parts. Biomass contains cellulose, a complex carbohydrate that is the main source of energy for biofuels. Cellulose can be further broken down into simple sugars using a variety of methods involving heat, chemicals, acids, microorganisms, or enzymes. These sugars are then fermented using yeast or other microorganisms to produce alcohols like ethanol or isobutanol, the foundation for jet fuel.

During the conversion process, biomass that does not get turned into fuel can be converted into co-products such as chemicals or bio-plastics. The sale of these co-products can help make the whole process more economically sustainable.

Distribution and Consumption

It is likely that transporting biofuels to airports would be done using the same infrastructure that is used for fossil fuel transport. The Pacific Northwest has five main oil refineries in Washington State and petroleum products are transported via pipelines, barges, and trucks. Jet fuel is heavier than other fuels and is best shipped via trucks and barges. These transportation networks take refined fuels to storage facilities near airports or fuel terminals. This is where biofuels would be blended with petroleum-based jet fuel. Blended jet fuel would then be sent to airports using existing distribution systems.

Sustainability Factors: Woody Biomass	
Greenhouse Gas Emissions (GHG)	Some information suggests that using forest residuals for fuel emits less GHG than burning them or leaving them to decompose. One study showed that gathering forest residuals at the roadside and changing them into ethanol produced 2-3 times fewer GHG. This study included transportation and processing.
Food Security	Using woody biomass for fuel presents few concerns about food security.
Conservation	Collecting woody biomass may impact wildlife and ecosystems. Some stakeholders feel that using forest residuals for fuel does not create conservation issues if it only involves biomass from current logging operations.
Soil	Impacts on soil quality should be evaluated, especially potential soil compaction from equipment, nutrient removal, and increased erosion. Many stakeholders disagree on the soil impacts caused by removing forest residuals for biofuel production.
Water	Impacts on water quality should be evaluated, such as the effects of increased traffic on logging roads and how increased biomass removal might impact runoff and stream sedimentation.
Air	Converting logging slash and other biomass into biofuels has minimal air impacts. If slash is burnt, as is currently done in some logging operations, it produces fine particulate matter and hurts air quality.
Other Concerns	Forest products are also desired for other markets, meaning there is competition for woody biomass. Many are concerned that using forest products for biofuel is harmful to the forest ecosystem. The cutting and concentrating of woody biomass before shipping it must meet environmental regulations.

Lesson 9

Sustainable Flight: A Stakeholder Meeting

Students take on perspectives of different stakeholder groups in the Pacific Northwest tasked with determining a sustainable aviation biofuel mix for the region. Stakeholder groups are encouraged to form alliances, contemplate compromise, and seek consensus on a policy that will best fit the needs of the whole community. Lesson 9 is a continuation of this unit's PBA.

MARK EATON

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Objectives

Students will:

- model a variety of negotiation styles
- appreciate different perspectives on aviation biofuels
- negotiate a sustainable aviation biofuel mix policy for the Pacific Northwest

Inquiry/Critical Thinking Questions

- How are effective styles of negotiation chosen?
- How does a stakeholder represent a group's interests and concerns effectively in a negotiation?
- What is a sustainable aviation fuel mix for the Pacific Northwest?

Time Required

Two 60-minute classes

Key Concepts

- **consensus building**—The process of working towards a general agreement among several parties that is sufficient to make a decision and carry it out.
- **fuel mix**—The amount and type of energy sources used to supply the energy demands of a particular region.
- **negotiation**—A dialogue between two or more parties with the goal to resolve a difference, to come to an agreement on something, or to create an outcome.
- **perspective**—A point of view or particular attitude toward something.
- **stakeholder**—A person or group that has a vested interest in a decision being made.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

3.6 Humans are part of Earth's ecosystems and influence energy flow through these systems.

4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.2 Human use of energy is subject to limits and constraints.

4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.

MICHAEL THIRNBECK

5.4 Energy decisions are influenced by economic factors.

5.6 Energy decisions are influenced by environmental factors.

5.7 Energy decisions are influenced by social factors.

7.1 Economic security is impacted by energy choices.

7.2 National security is impacted by energy choices.

7.3 Environmental quality is impacted by energy choices.

Materials/Preparation

Before class, retrieve 2 advertisements on Craigslist, one for the sale of an item *(e.g., car, concert tickets, cell phone)* and one for the sale of a service *(e.g., mechanic, hairdresser, personal trainer).*

Before class, retrieve the following lesson on negotiation styles for reference during Day 1's Introduction:

> **Lesson:** *Identifying Your Conflict Style*
> http://www.buildingpeace.org/sites/usip.qorvisdev.com/files/GPC_EducatorToolkit-(HighSchool)_combined.pdf
> Lesson 2.4 in the *Peacebuilding Toolkit for Educators* (High School Edition) provides teachers with tools on how to practice different negotiation styles. Edited by Alison Milosfsky. (Washington, D.C.: Endowment of the United States Institute for Peace Press, 2011).

Handout: *Stakeholder Profiles,* 1 profile per group

Handout: *Agenda,* 1 per group

Refer to the PBA Packet for:

Scenario: Sustainable Flight in the Pacific Northwest;

Product 3: Stakeholder Position Analysis;

Product 4: Council Member Negotiation;

Product 5: Negotiation Self-Assessment;

Product 6: Final Recommendation Paper

Optional: Internet Access to conduct group research

Note: Each stakeholder group should have all of the 4 handouts, Feedstock Fact Sheets, from Lesson 8. You will also want to display each group's *Product 1: The Life of a Fuel Poster.*

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Activity—Day 1

Introduction

1. Ask students if they have negotiated before. For those that have, ask the students to describe the situation and have them explain strategies they may have used.
2. Let students know that there are multiple styles of negotiation. Today, they will practice 2 of these styles in pairs using Craigslist advertisements.
3. Refer to the *Lesson 2.4: Identifying Your Conflict Style* lesson referenced in the Materials/Preparation list to help define different types of negotiation styles *(i.e., avoiding, accommodating, compromising, competing, problem solving).*

   Note: You may choose to print out a portion of this lesson (e.g., page 55) as reference for students during their negotiations over Craigslist advertisements.
4. Pair students and distribute a copy of the Craigslist advertisement for the sale of an item to each pair. One student will represent the buyer and the other student will represent the seller. Instruct each student to choose a different negotiation style listed in *Lesson 2.4: Identifying Your Conflict Style* to use during the negotiation.

   Note: Students should come to an agreement on price and any other conditions they may choose. Some students may not be able to reach an agreement.
5. Instruct students to find a new partner and to choose a new style of negotiation to try. Distribute the Craigslist advertisement for the sale of a service and give student pairs 2 minutes to complete the second negotiation.
6. Bring the class back together and have each pair from both rounds report the final outcome. Tally outcomes for each advertisement on the board and ask students to reflect on what might have led to a variety (or lack of variety) among outcomes.
7. Ask students what they have learned from this experience. Ask students to reflect on the following questions:
   - After hearing other outcomes, do you believe you still reached a favorable outcome in your own negotiation?
   - What styles of negotiation did you find effective or ineffective?
   - What lessons from this activity will you keep in mind for your next opportunity for negotiation?

Steps

1. Have students turn to the *Scenario* handout in their packets. Remind them that they are now at the third bullet in the scenario where they will be meeting regionally to make decisions about what aviation biofuels to use in the Pacific Northwest region.
2. Ask students to define **stakeholder** *(a person or group with a vested interested in a decision being made).*

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3. In Think-Pair-Share format, ask students what community members might be involved in making decisions about what biofuels should be used for aviation in the Pacific Northwest.
4. Record student ideas on the board.
5. Explain to students that today they will be taking a closer look at 6 specific stakeholders involved in the development of biofuels in the Pacific Northwest.
6. Share with the class the 6 stakeholders they will be representing: the aviation industry, an environmental nonprofit, an oil company, a tribal organization, the U.S. military, and the U.S. Department of Agriculture.
7. Explain that small groups will represent 1 of these stakeholders at the Regional Council meeting to negotiate a sustainable fuel mix for the Pacific Northwest Region. The purpose of the Regional Council meeting will be to reach a consensus on a policy for a sustainable aviation biofuels.
8. Ask students about what factors might make this negotiation with these different stakeholders complex *(the number of different perspectives, the different kinds of feedstocks, considering sustainability).*

   Note: Remind students that because there will be a variety of different perspectives, the negotiation styles they learned will be important to use.
9. Divide the class into 6 groups and assign each group a different stakeholder. Distribute the appropriate *Stakeholder Profile* to each group.
10. Tell students that they will spend the remainder of the class period meeting in groups to learn more about their particular stakeholder and to prepare for the negotiation on Day 2.
11. As part of their preparation, tell groups that they will be completing *Product 3: Stakeholder Position Analysis.* Review the guidelines for this product with students.

    Note: Each stakeholder group will need the 4 different *Feedstock Fact Sheets* from Lesson 8 to use as supporting evidence in order for them to complete *Product 3.*
12. Give students the rest of the class period to review their profiles and to complete *Product 3.*

Activity—Day 2

Introduction

1. Position tables/chairs to form a circle.
2. Have each stakeholder group find seats together around the circle and take out their *Stakeholder Position Analysis*, which may be used as a reference during the negotiation.
3. Explain to students that at this stakeholder meeting, they will be using certain kinds of negotiation skills and will be assessed on these skills. Review *Products 4* and *5* from the performance-based assessment paying close attention to the rubrics for these products and the skills that will be assessed.
4. Present stakeholder groups with the *Agenda* handout. Explain to students that this agenda will be used to help guide the


BETSY J. ENSLIN

negotiation and each group is expected to address each topic on the agenda.

5. Let students know that the goal of these negotiations will be to reach **consensus** *(general agreement among several parties that is sufficient to make a decision and carry it out).*
6. Give stakeholder groups 5 minutes to review their documents and prepare for the negotiation. Encourage groups to figure out how all group members can have a chance to speak during the negotiation.

Steps

1. Tell students that today you are a representative from the federal government here to facilitate the stakeholder meeting negotiation.
2. Begin with the first item listed on the *Agenda,* and have each stakeholder group briefly introduce themselves to the rest of the class.
3. Allow students 25 minutes of negotiation (guided by *Agenda* items II, III, and IV) in an effort to reach consensus on a final policy.
4. As the facilitator, you will take notes on the board to keep track of ideas and progress made toward a final policy. You will also regulate who talks when and for how long. Encourage students to present evidence from *Products 1, 2,* and *3* in support of the positions they take to ensure a well-informed discussion. Aside from the structure provided by the *Agenda,* you (as the facilitator) may decide how free form or controlled negotiations will proceed. If negotiations lag, you may want to pose one of the following questions:
   - What would be the ideal policy for each stakeholder? Where can we find common ground among these goals?
   - Are there concerns from stakeholder groups that have not been raised?
   - Do you think we have enough information at this time to reach consensus on a policy? If so, what would that policy look like? If not, what issues do we need to discuss further?

   If negotiations become too heated, you may want to pose one of the following questions:
   - Is there any common ground among stakeholder groups we can determine at this point?
   - What are challenges that are preventing us from reaching consensus?
5. If a final policy is reached, draft the policy language on the board. Make sure enough stakeholders are in agreement with the policy as it is written on the board to reach consensus.
6. When there are 15 minutes of class remaining, have students do a self-evaluation using the *Product 5* rubric.
7. With 5 minutes remaining, wrap up class with 1 or more of the discussion questions below.

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Note: The final product of the performance-based assessment is a culminating position paper in which students take a personal stance on aviation biofuels they believe should be used in the Pacific Northwest. Review *Product 6: Final Recommendation Paper* from their packets with them. Students may use the next class period to write this paper.

Discussion Questions

1. Was it difficult to achieve consensus? Why or why not?
2. Which stakeholder group did you find to be most persuasive and why?
3. Are there any other relevant stakeholders you felt were missing from the meeting?
4. How did preparing and participating in today's negotiations affect your views on sustainable transportation fuels?
5. After your study of energy and fuel, what do you think are the ideal characteristics of an energy source? How does this compare to your initial ideas at the start of the unit?
6. Why is it important to have many different stakeholders influence policy on biofuels?

Communications Extension

Have students identify two biofuels specific for their region. They can divide up into two teams and have a debate related to these pros and cons of these two biofuels. After having the debate, discuss the difference between a debate and a negotiation.

Service Learning Idea

Invite a guest speaker that works on negotiations and conflict resolution to come in and speak to your students. Based on tools that the guest speaker shares and research the students do, have them share negotiation/conflict resolution tips with their school community. The following resource may be helpful for continued work around negotiations:

- **Website:** *United States Institute of Peace: Global Peacebuilding Center*
  http://www.usip.org/about-us/global-peacebuilding-center
  This website provides resources for teachers and students that work to engage the next generation of peacebuilders.

Additional Resources

- **Book:** *Working It Out: A Handbook on Negotiation for High School Students*
  http://www.pon.harvard.edu/shop/working-it-outa-handbook-on-negotiation-for-high-school-students/
  This handbook offers tips on teaching high school students about negotiation skills, such as understanding different perspectives and knowing when to walk away from the negotiating table.
- **Lesson:** *Identifying Your Conflict*
  http://www.buildingpeace.org/train-resources/educators/peacebuilding-toolkit-educators/peacebuilding-toolkit-educators-high-schoo
  This lesson from the Peacebuilding Toolkit for Educators helps students identify different negotiation styles.

Stakeholder Profile: Aviation Industry

You are a representative of Boeing. Not only do you lead the world in aerospace, but you are also the world's largest manufacturers of commercial jetliners and military aircraft.[2] As you can imagine, jetliners and aircraft use a lot of fuel. The Boeing 747, for example, burns about 36,000 gallons of fuel over the course of a 10-hour flight—that's about 5 gallons of fuel per mile.[3] Jet fuel is created from oil and burning it creates greenhouse gases. In fact, carbon dioxide emissions from international aviation increased 83% from 1990 to 2006.[4] In 2012, flights created approximately 689 million tons of CO_2.[5]

As an aviation stakeholder, Boeing would like to help reduce commercial aviation's greenhouse gas emissions. Economic hurdles are increasing as rising fuel prices pose problems for airlines. There is also pressure on the aviation industry from governments to reduce emissions. You have been working with several different groups in the Pacific Northwest to create a regional aviation fuel mix that includes a greater share of biofuels. When biofuels are developed in sustainable ways, they help reduce greenhouse gas emissions because the growth of biofuel crops cycles CO_2 already in the atmosphere. CO_2 is taken up as feedstock plants grow and released when biofuels are burned, so that no new CO_2 is added to the atmosphere. You have done quite a lot of research into possible feedstocks to identify those with the greatest environmental, social, and economic benefits. You also want to ensure you develop biofuels that do not compromise land and water needed for food crops.[6]

Since you believe this is a global effort, you have been working with people from around the world including Brazil, Australia, China, and the United Arab Emirates to advance more sustainable aviation biofuels.

A lot of work goes into developing fuels and testing them to make sure they are safe. Before a jet fuel can be used, there is a rigorous three-step process to determine if it is viable: fuel properties are tested (such as a fuel's freezing point and composition), fuel is tested to see if its properties work with instruments on airplanes, and fuel is actually tested in the jet engine. The jet engines are then taken apart so that engineers can check for corrosion.[7]

You have come across several challenges in our efforts to replace fossil fuels with alternative fuels. For instance, ethanol does not have the energy density of fossil fuels, meaning that it takes more ethanol to produce the same amount of work. Another challenge is that jet fuels must remain liquid at low temperatures, but biofuels tend to become solids and gel more quickly than fossil fuels. Finally, you need to determine whether there will be enough biomaterial to create these alternative jet fuels. As mentioned earlier, you don't want to use biofuels that need a lot of land to grow. For example, a flight from Seattle to Washington, D.C. uses approximately 29 gallons of jet fuel per passenger. If you chose soybeans as a biofuel, you would need about a half-acre of soybeans to meet the needs of that one flight.[8]

The right kind of biofuel, however, could cut aviation's greenhouse gas emissions by 60 to 80 percent.[9]

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Biofuels used for aviation may help significantly decrease greenhouse gas emissions.

Stakeholder Profile: Environmental Nonprofit Organization[10]

You are a member of the Natural Resources Defense Council (NRDC). NRDC is a nonprofit environmental organization with over 1.4 million members and online activists with a mission to protect Earth's natural resources. One issue NRDC is concerned with is climate change. NRDC believes global carbon dioxide emissions must be significantly reduced by 2050 to avoid the most devastating impacts of climate change, such as drought, sea level rise, and mass human migration. Air travel contributes 5% of current CO_2 emissions[11] and, currently, the International Civil Aviation Organization estimates the use of aviation fuel will quadruple by 2050. Because most planes rely on fossil fuels to fly, this spike in the use of aviation fuels will amplify the impacts of climate change.

You are very interested in seeing the aviation industry become less dependent on fossil fuels. A switch to aviation biofuels could have a positive impact on the environment, economy, and national security. But you would caution those developing aviation biofuels to consider regional impacts. Choosing the wrong biofuel could lead to deforestation, habitat loss, air and water pollution, and food insecurity. For example, palm oil plantations have grown very popular in Indonesia and Malaysia as a food and fuel source. However, it is estimated that over the past two decades palm oil plantations have cleared 6,200 square acres of forested land. There are concerns that indigenous people are being pressured to move from their ancestral homes so these lands may be cleared for more plantations. Additionally, migrants often hired to work the plantations have been denied legal documentation, health care, and other fundamental labor rights.[12] You feel it is important to choose a sustainable biofuel that creates jobs, supports labor rights, reduces carbon emissions, protects our land and water resources, and promotes energy and food security.

NRDC encourages the adoption of a sustainable certification process for biofuels, where an independent agency would verify any sustainability claims made by airlines or biofuel producers. Adopting a sustainability certification would also send a clear message to the market that the airline industry cares not only about reducing its carbon footprint but also about ensuring their fuel choices will support our society, economy, and environment. Other industries may take notice and follow the airline industry's lead by implementing their own sustainability certification process.

The federal government could also support the push for sustainable aviation biofuels by promoting and purchasing these biofuels. The U.S. Department of Defense is a major fuel consumer, burning through 12 million gallons of oil each day.[13]

One of the biggest challenges related to the production of biofuels is making sure enough of the fuel is available to meet market demand. Currently, aviation biofuels are not produced in large quantities. To produce on the scale needed to meet the airline industry's demand will require lots of growth as well as caution to avoid unintended consequences for our environment.

MICHAEL THIRNBECK

Palm oil plantations can provide food and fuel, but sometimes at the cost of deforestation and forced migration.

Stakeholder Profile: Oil Company

You are a representative from a major oil company in Washington State. Your company has been around for over 100 years and in that time you have introduced different kinds of gasoline into the U.S. market. Your scientists worked to provide gasoline for aviation engines during World War II. You've also had exploration teams that helped to discover oil and gas reservoirs in places like Texas and Louisiana.[14]

Six hundred oil tankers and 3,000 oil barges come through the Puget Sound in Washington State annually. They carry approximately 15 billion gallons of oil to five oil refineries in the area.[15] These refineries process 561,000 barrels of crude oil each day into gas, diesel oil, and jet fuel. Approximately 64.7 million gallons of gasoline are consumed every day on the west coast of the United States alone.[16] In the Pacific Northwest and around the country, oil is an extremely important natural resource. Nevertheless, demand for alternative fuels is increasing in the United States due to the pressures of climate change and energy independence. At the same time, it is becoming more difficult and expensive to find and extract crude oil.

As an oil producer, you must follow the Renewable Fuel Standard program. This program was created as part of the Energy Policy Act of 2005 and was the first renewable fuel mandate in U.S. history. It set a requirement that 7.5 billion gallons of renewable fuel be blended into gasoline by 2012.[17] When the Renewable Fuel Standard program was introduced, it initially received criticism from the oil industry. Why? Because support for biofuels means less profit for oil companies.

The U.S. transportation market is worth approximately $500 billion.[18] The Royal Dutch Shell Company recently predicted that while only 1% of the world's transportation fuels are biofuels today, this could increase to 10% in the next decade.[19] Your company realizes that while you may be losing a portion of your profit to biofuels, biofuels aren't going anywhere. On the contrary, demand for biofuels has only increased in recent years. This is a new market and it could be unwise for you not to get involved in supporting it.

Your company has looked closely at biofuel options. You support biofuels that are made from waste and nonfood sources. You've learned from the past that ethanol produced from corn can corrode pipelines and has also been associated with raising food prices. Instead, you prefer biofuels made from sugarcane, algae, and wood waste.[20]

Your company has decided to make small investments in these kinds of biofuels. You understand the demand for alternative fuels and their environmental benefits, but you still think that aviation needs oil. You're not ready to dismiss all the work your company has put into building an infrastructure that can meet the energy needs of the aviation industry today.

BETSY J. ENSLIN

Due to the pressures of climate change and energy independence, demand for alternative fuels is increasing.

Stakeholder Profile: Tribal Interests

You are a representative from the Council of Energy Resource Tribes (CERT). CERT is comprised of 57 native tribes from both the United States and Canada. The organization was founded to advise and support tribes on energy projects.[21] CERT also strives to maintain a respectful relationship between tribes and the federal government in order to participate in resource management and environmental regulation.

Many Native American tribes have a "long-term, place-based perspective on resource management."[22] Tribal communities are closely connected to the land; they depend on it for survival and it is central to their cultural identity. As a result, tribes see how different energy resources impact the land and water and they appreciate the importance of understanding these linkages. For example, Northwest tribes have been observing the impacts of hydropower on the water, the land, and the fish for over 70 years.[23]

CERT believes the development of renewable alternatives to petroleum-based aviation fuels would support a more sustainable future for both tribes and the region. Biofuels offer a significant economic opportunity to tribal lands where biofuel feedstocks could be grown or harvested. Some tribes, such as the Confederate Salish and Kootenai Tribe, manage hundreds of thousands of acres of forestland that has supported a timber industry for decades. In these forests, woody debris and logging waste on the forest ground is commonly burned to keep the forest healthy, giving the trees much needed space and ensuring the debris does not add additional fuel to forest fires.[24] Now biofuel developers are considering the potential of this woody debris for use in aviation biofuels. Tribal land can also be used to grow other feedstocks like algae, to develop refineries that can process jet fuel, and to build waste-to-energy plants that convert waste biomass to energy projects.[25]

Many tribes suffer from high rates of un- or under-employment,[26] making the economic opportunities provided by biofuels an attractive prospect. Overall, the tribes are seeking to grow their economies, provide employment for tribal members, and reconnect with their culture and land; if this can be done through the sustainable harvest of natural resources found on tribal lands for aviation fuel, all the better.

CERT's objective is to use sustainability as a guiding principle for any biofuel projects. To be sustainable, a project should preserve Native American heritage, emphasize social equity, undertake an environmental risk assessment, and create jobs and profits for all stakeholders.[27] You are concerned about how climate change may affect natural resources and how new biofuel technologies may impact native tribes, and you think these issues need to be studied.[28] When examining different technologies and fuel resources, it's important to you that all aspects of a fuel's life cycle be considered to find resources that can continue to meet the needs of future generations.[29]

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For decades, many tribes have helped manage forestland that has supported the timber industry.

Stakeholder Profile: U.S. Military

As a member of the U.S. military, you want to express your support for the development of biofuels. Much of what you do requires fuel, such as the operation of aircraft and ground vehicles. The Pentagon is the largest consumer of petroleum-based fuel in the United States; the largest share of the Department of Defense's oil goes to aviation.[30] But this huge need for oil in military operations puts soldiers and the American public at risk. One study conducted by the Army found that for every 24 fuel convoys sent out in Afghanistan or Iraq, 1 soldier was hurt or killed.[31] Another study showed that over 3,000 soldiers or private contractors have been killed in attacks on fuel or water convoys.[32]

Because fuel is so important to U.S. national security, we need a reliable supply in order to be prepared at all times to protect the American people. But our country's reliance on oil leaves us vulnerable to disruptions in supply. We import most of our oil from other countries and global politics can interrupt or limit oil imports, as happened in the oil embargoes of the 1970s. More recently, Hurricanes Katrina and Sandy have demonstrated that natural disaster can also impact our ability to refine oil. The development of alternative fuels that could be produced domestically is needed to protect soldiers and the people of our country.

Some people argue that biofuels are too expensive and that the military should not invest its money into biofuels. But oil is expensive, too! Every time the price of a gallon of oil increases by $1, $130 million is added to the military's energy bill.[33] Furthermore, once you create the technology and market for biofuels, the cost to produce them will decrease. Many people forget that the Department of Defense has often promoted the use of cutting edge technologies like cell phones, computers, and GPS systems.[34] Biofuels should also be a part of this story.

Also, like many other agencies, the U.S. military is under increasing pressure to reduce greenhouse gas emissions in order to comply with new environmental regulations from federal and state governments as well as from some foreign countries.[35] The military must meet the requirements of these changing regulations to have access to foreign ports and territories. Mobility is key to the military's mission to promote peace and security, and investments in alternative fuels like aviation biofuels are an essential part of adapting the U.S. military to today's energy challenges.

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Much of what the military does requires fuel. The Pentagon is the largest consumer of petroleum-based fuel in the United States.

Stakeholder Profile: U.S. Department of Agriculture

You are an area director from the U.S. Department of Agriculture Rural Development (USDA-RD). The USDA has already provided a lot of support for the development of advanced biofuels in the United States and you are committed to continuing this support. You are well aware that creating alternative fuels can improve national security by reducing the need to buy oil from other countries, and you know it could also decrease carbon dioxide emissions by replacing fossil fuels with a renewable source of energy. You are particularly interested in alternative fuels made from agricultural products like woody biomass, grasses, or oilseed because of their potential to strengthen the American rural economy.[36]

There are several reasons why you think it is important for the United States to strengthen its rural economies. First of all, around 17% of the U.S. population lives in rural areas (areas with relatively low population density)— that is about 50 million people.[37] Compared to the rest of the country, people living in rural areas typically earn lower incomes and have higher rates of poverty. Also, the age of the workforce in rural America has grown older as younger generations move to cities or towns with more opportunities.[38] The development of a biofuels industry in rural areas would create jobs, raise rural incomes, and give people a reason to stay in these areas. There are possible environmental benefits, too. If a region's natural resources were used to create biofuels and other products, this would increase their economic value. This increased economic value might encourage regions to protect those natural resources more and seek out ways to make the biofuels industry more sustainable.

The USDA is doing a lot to help make an alternative biofuels industry a reality. It has partnered with the Federal Aviation Administration (FAA) to research feedstock options and develop policies that encourage the production of alternative jet fuels.[39] Additionally, the USDA is able to offer billions of dollars in loans for people in rural areas seeking to start up renewable energy companies.[40] This can help reduce the financial risk for people investing in a new market.

While all U.S. states have some rural areas, the western states have an especially large amount of rural areas. The Pacific Northwest seems like a great place to create a whole industry around biofuels. There are major universities that can research feedstocks and train people to work in the biofuels industry, forest industries that produce wood waste that can be converted into jet fuel and other products, and aviation leaders like Boeing that can contribute expertise on airplanes and jet engines. The idea to create a biofuels industry in the Pacific Northwest seems like a win-win situation; developing a strong biofuels industry would help people living in rural areas as well as those that use jet fuel—including our military and commercial airlines.

The USDA wants to help grow the biofuels industry. The federal agency has provided billions of dollars in loans for people living in rural areas seeking to start up renewable energy companies.

Agenda: Meeting of the Pacific Northwest Regional Biofuel Council

I. Introductions (5 minutes)

II. Discussion of Aviation Biofuel Options for the Pacific Northwest (10 minutes)

A. What fuel sources should we consider and why?

B. What other factors should we consider and why?

III. Policy Recommendations from Stakeholders (10 minutes)

A. What components should be included in a policy?

B. How can we ensure the most economically sustainable policy is chosen?

C. How can we ensure the most environmentally sustainable policy is chosen?

D. How can we ensure the most socially sustainable policy is chosen?

IV. Draft Policy Language (if agreement is reached) **OR** Discuss Next Steps (if agreement is not reached) (5 minutes)

Pre and Post Assessment

Name Date Class

Pre and Post Assessment: Content Knowledge, page 1

Recall

Match the following words on the left with their definitions on the right.

1. biofuel	energy cannot be created or destroyed, but it can be transferred or transformed
2. fossil fuel	fuel made from biomass, used mostly for transportation
3. law of conservation of energy	the principle of meeting current needs without limiting the ability of future generations to meet their needs
4. sustainability	a nonrenewable energy source created when plants and animals are exposed to heat and pressure over a long period of time

Reasoning/Explanation

Complete the following multiple choice questions by choosing 1 correct answer.

5. Which of the following is an example of kinetic energy?

a. a battery in a flashlight
b. a water reservoir
c. uranium-235
d. wind

6. Which of the following is a nonrenewable source of energy?

a. geothermal energy
b. hydropower
c. petroleum
d. solar energy

7. Which of the following statements describes a trade-off of using hydropower to generate electricity?

a. Building dams for hydropower plants can displace people from their homes.
b. Hydropower is a nonrenewable source of energy.
c. Hydropower produces a large amount of carbon dioxide.
d. Water reservoirs built for dams create recreational activities for local people.

Pre and Post Assessment: Content Knowledge, page 2

8. How can using electricity contribute to climate change?

a. Burning fossil fuels to generate electricity produces carbon dioxide.

b. Lightning causes changes in the ozone.

c. Nuclear power plants produce radiation which increases the amount of carbon dioxide in the atmosphere.

d. The heat lost from electrical wires contributes to rising global temperatures.

9. Coal is an abundant and inexpensive energy source in the United States. When burned it produces cheap electricity as well as pollution that can harm ecosystems and human health. According to this information, coal could be considered a sustainable energy source in which of the following categories?

a. economy

b. environment

c. society

d. all of the above

10. The flow chart below describes the stages of the supply chain for any given fuel. Based on the supply chain for biofuel made from oilseed, which of the following is the most likely environmental impact of the feedstock stage?

The Supply Chain of a Fuel

Feedstock → Extraction → Transportation → Conversion → Distribution → Consumption

↓ (from Conversion)

Co-product

a. Only a small portion of oilseed meal can be added to animal feed because it contains chemicals that interfere with animal reproduction.

b. Burning biofuel made from oilseed in a car produces carbon dioxide and reduces air quality.

c. Growing oilseeds requires a large amount of freshwater.

d. Fertilizers and herbicides that are commonly used to grow oilseeds can impact soil health.

Pre and Post Assessment: Content Knowledge, page 3

11. Which of the following statements best explains how current global energy use could be considered environmentally unsustainable?

a. Energy use is the largest contributor to human-generated carbon dioxide emissions.

b. Not all people around the globe have equal access to electricity.

c. The use of nonrenewable energy sources can encourage international conflict.

d. The use of renewable energy sources contributes to the greenhouse effect.

12. Brazil is the 9th largest energy consumer in the world. The country's primary energy consumption increased by 1/3 in the last decade because of its consistent economic growth. The country is the 2nd largest producer of ethanol after the United States. Brazil also produces a significant amount of petroleum.[1] Which of the following would represent a sustainable energy policy for Brazil as the population increases and the energy needs increase?

a. increased production of petroleum to both export and supply all citizens

b. increased energy infrastructure such as oil pipelines and power stations

c. increased use of local, renewable energy sources to provide accessible energy for all citizens

d. increased use of farmland to produce biofuels in order to help the country economically develop

13. Which of the following best demonstrates an example of energy efficiency?

a. turning off the lights when leaving a room

b. replacing regular light bulbs with LED light bulbs

c. unplugging appliances when not using them

d. opening a window during the summer instead of using air conditioning

14. All of the following are reasons aviation stakeholders in the United States are interested in creating aviation biofuels, except:

a. Importing less oil can improve national security.

b. Burning oil produces greenhouse gases that contribute to climate change.

c. The biofuels industry creates more jobs than the oil industry.

d. Oil is a finite resource.

Pre and Post Assessment: Content Knowledge, page 4

Application/Complex Reasoning

On a separate piece of paper, answer each of the following short answer questions:

15. You are part of a stakeholder meeting to determine whether a wind farm should be built in a local community. Read the following scenario and then answer the questions below.

Your local government is considering building a wind farm in the rural farming community where you live. The community has limited access to electricity, so this is an exciting prospect. The government has convened a stakeholder meeting after gathering input from various community leaders about the advantages and disadvantages of the proposed project.

The following comments and concerns have been voiced:[2]

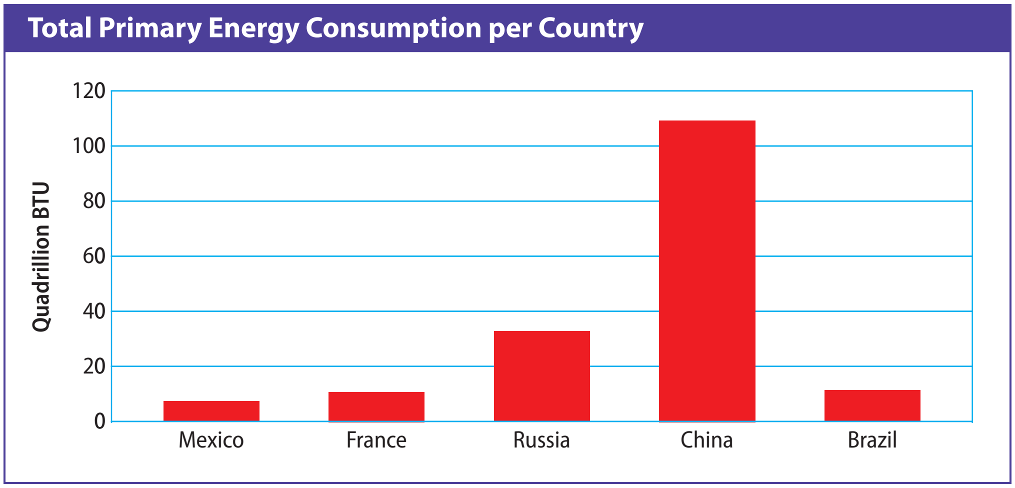
Pros of building a wind farm	Cons of building a wind farm
• Wind farms generate little to no air pollution when compared to the air pollution generated from the burning of fossil fuels. • The construction and operation of the wind farm will create jobs, increasing employment in the community and developing its economy. • The wind farm will generate electricity that will power lights and appliances and irrigate the land.	• Wind turbines will need to be transported to the wind farm in large trucks. This may damage local roads. • There will be less land available for cows to graze on. Raising cattle is one of the biggest contributors to the local economy. • The sound made by wind turbines is loud and disruptive, especially at night. • Wind turbines can kill large numbers of birds when birds fly too closely to active turbines or when birds land on inactive turbines and are caught when the blades begin to move.

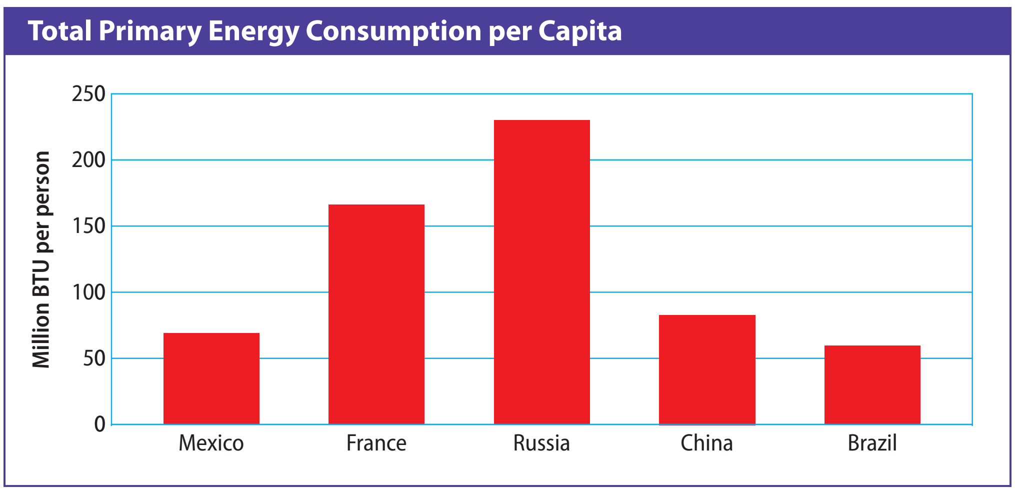
Part A. After reading the scenario and the pros and cons of the proposal, identify 3 possible stakeholders you believe would attend this meeting.

Part B. Some stakeholders have raised concerns about the proposed wind farm. Identify two concerns and suggest sustainable solutions that would address them.

Pre and Post Assessment: Content Knowledge, page 5

16. Review the following graphs. Then answer the questions below.





Source: "Total Energy," EIA, under International Energy Statistics, accessed April 18, 2013, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=2.

What is one thing that you can infer from the information shared in both of these graphs? Use evidence to explain this inference.

17. Read the quote below to answer the questions that follow:

"Energy is the golden thread that connects economic growth, social equity, and environmental sustainability."[3]

—UN Secretary-General Ban Ki-Moon

Part A. Explain how energy is related to economic growth.

Part B. Explain how energy is related to social equity.

Part C. Explain how energy is related to environmental sustainability .

Name Date Class

Pre and Post Assessment: Personal Attitudes and Beliefs, page 1

How much do you agree with each of the statements below? Give your response using a scale from 1 to 5, where 1 means you strongly disagree and 5 means you strongly agree.

1 = strongly disagree **5 = strongly agree**

1. We should get more of our electricity from renewable resources.[4]

1 **2** **3** **4** **5**

2. We should continue using petroleum for transportation fuel.

1 **2** **3** **4** **5**

3. My personal energy use has local and global impacts.

1 **2** **3** **4** **5**

4. I believe I can contribute to sustainable energy solutions by making appropriate energy-related choices and actions.[5]

1 **2** **3** **4** **5**

5. I believe Earth has limited energy resources.

1 **2** **3** **4** **5**

6. I know where my electricity comes from.

1 **2** **3** **4** **5**

7. I believe there is a connection between energy and sustainability.

1 **2** **3** **4** **5**

Name Date Class

Pre and Post Assessment: Personal Attitudes and Beliefs, page 2

8. Based on your response to #7, explain your thinking:

9. Two ways I can use energy more efficiently include:

10. Two ways I can conserve energy include:

Teacher Master: Pre and Post Assessment

Recall (4 points)

1. biofuel—fuel made from biomass, used mostly for transportation
2. fossil fuel—a nonrenewable energy source created when plants and animals are exposed to heat and pressure over a long period of time
3. law of conservation of energy—energy cannot be created or destroyed, but it can be transferred or transformed
4. sustainability—the principle of meeting current needs without limiting the ability of future generations to meet their needs

Reasoning/Explanation (10 points)

5. D	**10.** D
6. C	**11.** A
7. A	**12.** C
8. A	**13.** B
9. A	**14.** C

Application/Complex Reasoning (11 points)

15. Part A. Answers will vary. Possible answers include: (1 point)
- farmers and ranchers
- environmentalists
- scientists
- economists
- landowners
- local business owners
- community residents

Part B. Answers will vary. Possible answers include: (2 points)
- Build the wind farm away from residential areas so that homes are not disturbed by the sound.
- Negotiate the amount of land to be used for the wind farm with local farmers and ranchers to ensure their economic livelihood.
- Ask trucking companies or wind farm companies to provide money to fix the roads on an annual basis so that they are not continuously destroyed.

16. Answers will vary. Possible answers include: (2 points)
- China probably has a larger population than Russia because China's per capita energy use is less than Russia's while their country's energy use is more than Russia.

17. Part A. Answers will vary. Possible answers include: (2 point)
- Energy is required to manufacture products, run businesses, and pursue other economic endeavors.
- People who lack access to basic energy services may have to collect biomass for fuel. This can prevent them from attending school or a paid job.

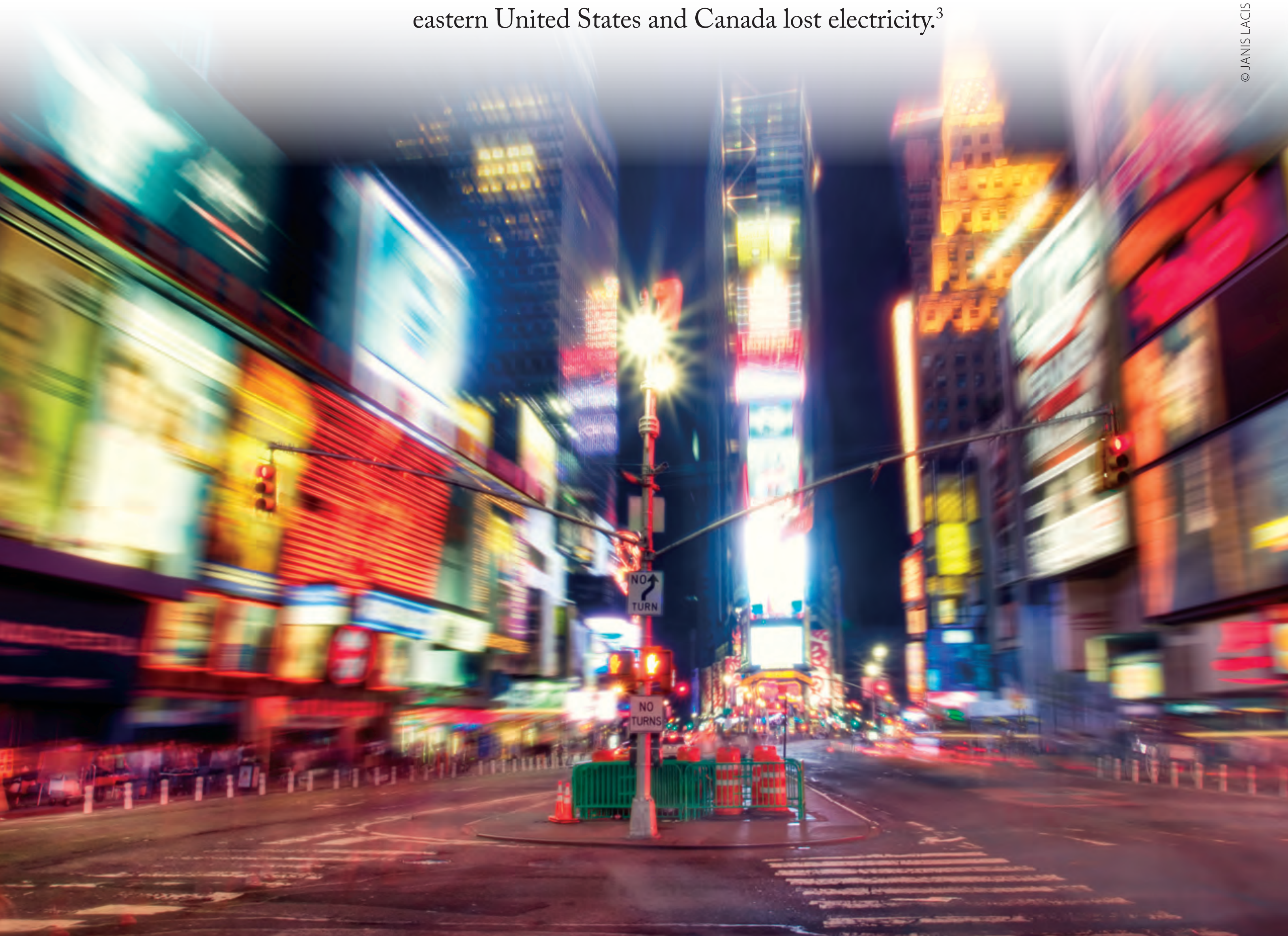
Part B. Answers will vary. Possible answers include: (2 point)
- People who lack access to basic energy services may have to collect biomass for fuel. Often this burden falls on women and children and prevents them from attending school or a paid job. This contributes to gender inequity.
- Lack of light can prevent children from studying at home and limit the accessibility of education in poor or rural areas without electricity.
- Those that cook and heat their homes with biomass or coal can suffer health problems from indoor air pollution. Kerosene lamps also produce indoor air pollution.

Part C. Answers will vary. Possible answers include: (2 point)
- Energy use is the largest contributor to human-produced carbon dioxide emissions.
- Each energy source has some environmental costs. For example, wind turbines kill birds and bats.
- Most energy used in the world today comes from fossil fuels, which are nonrenewable.

Reading 1

Introduction to Energy

On a hot summer day in 2003, New York City subways halted and traffic lights went out. A New England Six Flags roller coaster was stopped mid-ride. Over one million residents of Cleveland were faced with dry faucets from out-of-order water pumps,[1] while New York residents were flooded with offers of $1 ice cream bars from store owners who lost refrigeration.[2] During the blackout of 2003, 50 million people in the eastern United States and Canada lost electricity.[3]



What would a day in your life look like without electricity? For many of us, electricity is a modern convenience that we often take for granted. We know that light turns on when we flip a switch, but we may not know if this electricity was generated by burning coal or damming a river. Knowing how we use energy and where our energy comes from can help us make effective energy choices for a sustainable future.

What Is Energy, Anyway?

In our everyday conversations, we often use the term energy to describe many different things: our mood, a sports drink, electricity, and so on. But what is energy, really? Scientists define **energy** as the ability to do work or cause change. This means that some form of energy is required for an object or a system to do things such as move or generate heat and light.

Take a car, for instance. What form of energy is necessary in order to drive a car down the road? Most cars use some sort of chemical energy such as gasoline to fuel the engine. When you start the car, the internal combustion engine transforms this chemical energy into motion energy and before you know it you're cruising down the road. Without the energy gasoline provides, the car wouldn't go anywhere.

While there are many different forms of energy such as light, heat, motion, and chemical energy, they can all be classified as either potential or kinetic. **Potential energy**—such as gasoline—is a type of stored energy. When gasoline is burned in an engine, this potential energy is transformed into **kinetic energy**, or the energy of motion. One type of energy can be transformed into another or transferred to a different object. However, energy is never created or destroyed. In fact, there is a constant amount of energy in our universe.

If energy can never be destroyed, then why are so many people concerned with saving or conserving energy? Energy can be converted into forms of energy such as heat that are less useful and less observable. Imagine pumping gasoline into a car's gas tank. When burned in the engine, about 14-26% of that gasoline is used to move the car forward; a large amount of the remainder is turned into heat.[4] If you have ever touched the hood of a car after it has been driven, you know that some of this heat warms the body of the car. The rest of it heats up the surrounding air or ground. Unfortunately, this is not a form of energy that we can collect and put back into the tanks of our cars. Therefore, this energy is often referred to as "lost" energy.

Scientists define energy as the ability to do work or cause change.

In fact, most machines that use energy (including the human body) waste large amounts of energy. For example, many power plants that generate electricity are only 35% efficient.[5] This means that for every three units of fuel used to generate electricity, only one unit of electricity is produced. As with a car, most of the remaining energy is released to the surrounding environment as heat.

Human Energy Needs

Like cars, humans depend on energy to function. First and foremost, we must have energy to stay alive. Energy provided by the foods we eat and the beverages we drink powers the basic operations of our cells and allows our bodies to function on a day-to-day basis. The amount of energy in our bodies also determines our ability to fight off disease and to think clearly.

In addition to these basic biological needs, we use energy to perform work and raise our comfort level. For example, energy is used to charge our computers, light and heat our homes, and fuel our transportation. It is also required to manufacture goods such as medicine, clothing, and food. And, how do all of these products get to the store? Energy, of course.

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energy—The ability of a system to do work or cause change.

potential energy—Stored energy, or forms of energy (such as gravitational potential energy) that result from an object's position or relationship with another object.

kinetic energy—Working energy, or the energy of motion.

Our Primary Source: The Sun

Where does all of this energy come from? The sun is the main source of energy on Earth. The sun's uneven heating of the air, water, and land produces wind and rain that can be used as energy sources to do work for us.[6] Sunlight is also captured by photosynthesizing organisms such as plants and algae and used to produce chemical energy. Humans and other animals that cannot directly use energy from the sun can get the energy they need by eating plants or other animals that feed off plants. Directly or indirectly, the sun is the original source of food energy for most living organisms on Earth.

In addition to providing food, the sun is one of the primary sources of energy used to power human society. Solar cells capture sunlight directly and use it to create electricity. There is also an indirect source of solar energy which provides people with a way to harness sunlight that was emitted millions of years ago! Light captured by plants millions of years ago has been stored as chemical energy in fossil fuels. **Fossil fuels** are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure which transforms them into fossil fuels in the form of coal, oil, and natural gas.

Solar energy is captured by photosynthesizing organisms such as plants and algae.

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Renewable or Not?

Light and heat are constantly generated by the sun; therefore, solar energy is considered a renewable energy source. A **renewable** energy source is one that is replenished naturally and quickly. Sun, wind, and water power are all examples of renewable energy.

Alternatively, a **nonrenewable** energy source cannot be replaced in a short amount of time. Fossil fuels like coal, oil, and natural gas are considered nonrenewable energy sources because it takes so long for these energy sources to form.

Energy and Sustainability

The amount of energy that the world consumes has been steadily increasing and experts predict that our consumption will continue to increase in the next couple of decades.[7] There are two main energy challenges our world faces. One is that many people around our world still do not have access to reliable forms of energy. Another is that the majority of the world's energy is supplied by oil, coal, and natural gas—all nonrenewable forms of energy that release greenhouse gases when burned.

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fossil fuel—A nonrenewable energy source created when plants and animals are exposed to heat and pressure over a long period of time.

renewable energy source—An energy source that can be replaced quickly and naturally.

nonrenewable energy source—A limited energy source that cannot be replaced in a short amount of time.

Energy and sustainability are inextricably linked with each other.

Economy

In general, as countries become more developed their energy consumption increases. This can improve quality of life for some, but that improvement comes with costs such as pollution. For instance, as countries become more developed and incomes rise, more manufacturing occurs and more cars are on the road, leading to even higher use of fossil fuels. If current conditions continue, India is projected to have the highest car density in the world by 2050.[8]

As more and more countries seek to develop their economies, competition may increase for nonrenewable fossil fuels that are already being depleted. Increasing energy costs—rising gas prices and food prices—can have serious economic and social consequences.

On the other hand, lack of access to energy resources can seriously hinder economic and social development. While many of us take our modern energy resources for granted, about one in five people do not have access to electricity.[9] Many machines and technologies such as farming equipment or computers require energy in order to work. Countries that lack the resources for energy-intensive forms of industry might not be able to develop economically and compete with energy-rich nations.

Society

Almost three billion people rely on traditional biomass such as wood, animal dung, or coal to cook their food.[10] How might lack of access to energy resources affect a person's opportunities for education, employment, and healthful living? For starters, collecting biomass fuel to cook with such as wood or animal dung is a time-consuming, physically demanding task that is usually borne by women and children.[11]

Time spent collecting fuel is time that is not spent in school or at a paying job. Furthermore, cooking with biomass or coal produces harmful air pollution that can cause serious health problems and even death. In fact, the number of deaths from air pollution inside the

CHRISTIE HEYER

Women and children are often tasked with collecting biomass.

home is estimated to be more than 1.45 million people per year.[12] Using local biomass without replacing it can lead to environmental degradation such as deforestation.

Environment

Energy use is currently the largest contributor to human-produced carbon dioxide emissions.[13] When fuels such as oil and coal are burned in an engine or at a power plant to generate electricity, carbon dioxide and other greenhouse gases are released. A **greenhouse gas** prevents reflected sunlight from leaving the earth's atmosphere and, as a result, enhances Earth's natural greenhouse effect. The greenhouse effect is named for its similarity to the way a greenhouse traps sunlight to make the temperature inside the structure much warmer than outside. As more greenhouse gases accumulate in the atmosphere, the average temperature on Earth goes up. This process alters Earth's climate.

Even before they are burned, the extraction of fossil fuels has significant potential to cause ecological damage. For example, extracting oil requires digging deep into the earth, which can affect landscapes and wildlife habitats. Furthermore, machinery used for extraction, production, and transport of fossil fuels often itself requires large amounts of fuel to operate.

Energy resources such as oil are often transported long distances from the site of extraction.[14] The gasoline at your local gas station traveled across many state lines and possibly even across oceans before reaching you. The distances likely involved in transporting oil and the methods used to extract it create the potential for accidents, such as oil spills, to occur.[15] One of the biggest oil spills in history was triggered by an explosion on the Deepwater Horizon oil rig in 2010. This caused an oil leak that released oil and gas into the Gulf of Mexico at a rate of 11,350 tons per day, or around 59,200 barrels of liquid oil per day into coastal waters.[16]

Oil spills can have serious consequences. Wildlife that comes into contact with spilled oil can be harmed or die. Even organisms (including humans) that have not come into direct contact with oil may be harmed if their food sources have been contaminated by oil. Beyond negative impacts on the health of animals and ecosystems, the people whose livelihoods depend on fishing and tourism can face severe economic consequences from an oil spill that may last for years. In fact, the widespread and varying effects of oil spills demonstrate the environmental, economic, and social repercussions of our energy use.

YOUTH PROFILE

Evans Wadongo

When Evans Wadongo was younger, the only way he could study was by the light of a kerosene lamp. His family had only one lamp and it was too weak for the whole family to use at once, restricting the amount of time Evans could study at night. Because of this, Evans

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greenhouse gas—A gas found in Earth's atmosphere that both absorbs and re-emits infrared radiation.

Evans stands with a recipient of the MwangaBora lantern.

didn't perform as well as he thought he could on exams. The dim light and smoke from the kerosene lamp also damaged his eyesight. Evans was not alone; in his village, many families did not have access to electricity. Many students who lacked proper lighting eventually ended up dropping out of school. Without a complete education, students like these often remain in poverty.[17]

Evans, however, did pursue his education and went on to study at a Kenyan university. One day, he had an idea for something that would transform his village: a solar-powered LED lantern (LED stands for light-emitting diode, a reliable, energy-efficient light source). An artisan helped him construct the lamp and family and friends helped him out financially. Evans named these lamps "MwangaBora," a term in Swahili meaning "better light."

Evans gained support for the project from the organization Sustainable Development for All—Kenya; eventually, the organization invited Evans to be a partner and chairman of the board. The lanterns are constructed by volunteers. Local women's groups and governments help determine which families are most in need of the lamps. Evans' goal is to create MwangaBora for people living in rural areas throughout Kenya. These lights have many benefits:

- Construction of the lamps leads to local jobs.
- Use of the lamps reduces the amount of money a family has to spend on kerosene.
- Use of the lamps gives more children a fair opportunity for education.
- Replacement of kerosene lamps with LED-powered lamps reduces respiratory illnesses, eye problems, and hazards for fires.[18]

CHECK FOR UNDERSTANDING

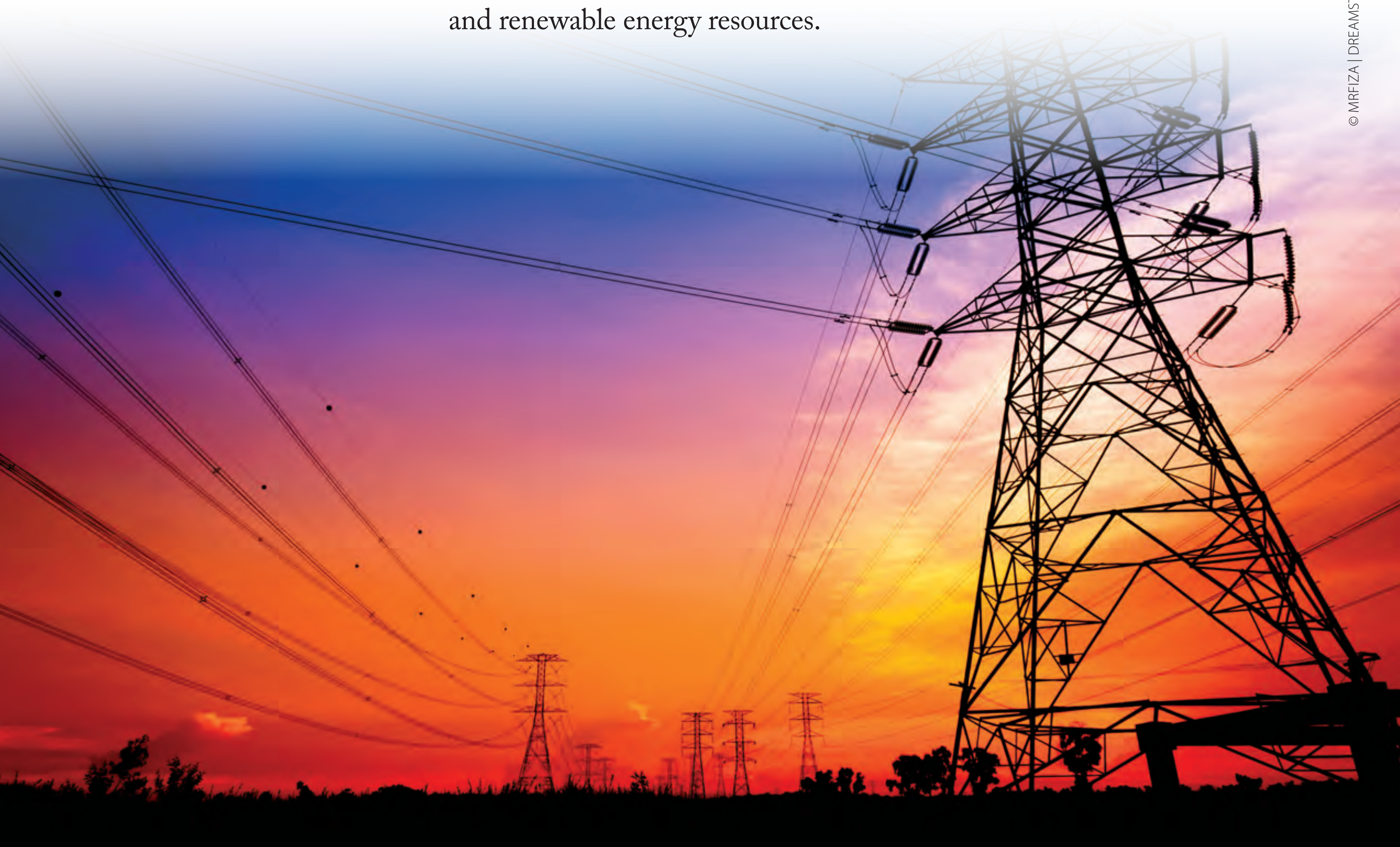
1. How do you use energy to meet some of your basic needs? How do you use energy beyond your basic needs?
2. What is the difference between potential and kinetic energy?
3. What is meant by the phrase "lost energy?"
4. How does energy use relate to the three components of sustainability: environment, economy, and society?

Reading 2

Energy Today

The world uses more energy today than ever before, thanks to population growth, increasing transportation of people and products around the world due to globalization, and technology-rich lifestyles that require a constant supply of energy. While oil remains the world's leading fuel, there are many other energy resources used around the globe. Are there limits to the amount of energy available to us? How do different energy sources compare? And how do we determine which energy sources are most sustainable?

The answers to these questions are central to finding a way for all people to use energy sustainably. When evaluating different energy sources, we must look closely at the economic, environmental, and social consequences of using each source of energy. In the following section, you can learn about the main pros and cons of different nonrenewable and renewable energy resources.



Nonrenewables

Nonrenewable energy resources are limited and cannot be replaced in a short amount of time. They include oil, natural gas, coal, and uranium.

Oil

The energy resource that the world uses more than any other is petroleum, or oil.[1] You probably know that oil is primarily used for transportation: it can be refined (processed) to produce diesel, gasoline, and even jet fuel. But did you also know that oil is an ingredient in many of the products we use? Medicines, shampoos, make-up, tires, and plastics can all be made from petroleum. So can clothes that are made with nylon, rayon, or polyester.[2]

Oil is a fossil fuel that is usually found deep within Earth. It is extracted by drilling down into Earth and pumping it up to the surface. Oil is not readily found everywhere around the globe, which is why many countries import oil from other countries. The largest **oil reserves** are found in Saudi Arabia and Venezuela.[3]

As with other nonrenewable resources, there is a limited supply of oil. This can increase competition for this resource and has historically led to international conflict. Countries that import a large portion of their oil have less control over the price and supply of this resource than they would over a domestic resource.

In addition, throughout most of its life cycle—from exploration and extraction to consumer use—oil is linked to pollution. The process of searching for and extracting oil is unpredictable and can impact the health of the surrounding environment. Transporting oil itself requires fuel and creates the potential for oil leaks or spills. Burning oil products in a car, jet, or power plant produces large amounts of pollution that can affect the health of humans, animals, and ecosystems.

On the other hand, one main benefit of using oil is that it is energy dense. **Energy density** describes the amount of energy stored in a given volume or space. In fact, oil is more energy dense than natural gas, coal, and biomass. Also, much of the infrastructure needed to refine and distribute oil is already in place. For example, pipelines, roads, gas stations, and most car engines are manufactured to support oil use. Because oil is a form of chemical energy, it can be stored until it is needed and since oil is a liquid, it is easier to transport than coal.

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Oil is a fossil fuel that can be extracted from underground reservoirs.

As sources of easily accessible oil are depleted, it will take more and more energy (and money) to extract oil from places that are harder to reach. As it becomes less lucrative to extract fossil fuels like oil, the rate of oil production may eventually begin to decline. Many people refer to this situation as peak oil.[4]

Natural Gas

Natural gas is another fossil fuel found in many places around the world. The largest natural gas reserves in the world are found in Russia.[5] Natural gas is mostly used as a heat source and as an ingredient in products like fertilizers, plastics, glue, and paint.[6] Although natural gas does emit some pollution when burned, it produces about half the carbon dioxide of coal and is the cleanest fossil fuel to burn.[7]

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oil reserves—The estimated amount of oil that is currently available and recoverable with existing equipment and under existing conditions.

energy density—The amount of energy stored in a given volume or space.

Natural gas is often transported through pipelines.

Natural gas has traditionally been extracted from underground reservoirs in porous rock by drilling vertical wells that average about 6,100 feet deep.[8] Once found, natural gas is usually transported from one location to another via underground pipelines. More than 300,000 miles of underground pipeline transport natural gas throughout the United States.[9] The pipelines are relatively cheap to maintain (though expensive to build) and many are already in place.[10]

Recent advances in technology have helped engineers capture natural gas that is trapped in shale formations (fine-grained sedimentary rock). Horizontal drilling and hydraulic fracturing, or fracking, are two techniques engineers use to obtain hard-to-reach natural gas. During hydraulic fracturing, water, sand, and chemicals are injected into underground wells to create cracks in the rock. This process forces natural gas up to the surface.[11] Horizontal drilling allows gas to be recovered parallel to rock layers rather than drilling deeper.

Horizontal drilling and hydraulic fracturing make it possible to extract more natural gas from each well. However, fracking uses a large amount of water and produces large amounts of wastewater. If wells are not properly installed, it also has the potential to leak chemicals into nearby water sources and ecosystems. Fracking may lead to land instability and in rare instances may even cause small earthquakes.[12]

Coal

A third type of fossil fuel is **coal**. Although it is less energy dense than oil or natural gas, it can still provide a good amount of energy. Coal is a relatively abundant and inexpensive energy source. In fact, the use of coal is expected to increase in future years, especially in developing countries.[13] Together the United States, Russia, and China have about 60% of the world's coal reserves.[14]

Most of the coal used in the United States is burned to produce electricity. Coal is also used to manufacture products such as steel, paper, and cement. Coal mining and the manufacturing that results from coal can encourage economic development by creating jobs in these sectors. For the many countries that mine it domestically, coal can be more economically and politically secure than oil.

Coal is extracted from the earth by either surface mining or underground mining. Surface (or strip) mining removes the land above coal deposits.[15] Sometimes explosives are even used to remove land above coal; this is called mountain top removal. The blasted earth often ends up in valleys or in waterways, which damages ecosystems, wildlife, and water quality. There have been some legislative attempts to control the pollution that results from this type of surface mining, but these laws have not always been successful.[16] Federal law requires mining companies to return blasted mountaintops to their original shape, but this does not often happen.[17]

In underground mining, equipment and workers go hundreds of feet below ground to extract coal. People who mine coal are exposed to many dangers: the ground above them can collapse and exposure to years of coal dust can cause health problems such as black lung disease.

Coal generates the most pollution of all fossil fuels. The extraction and combustion of coal releases many substances that can affect human health, damage the environment, and contribute to climate change. Burning coal is the leading cause of both sulfur and mercury pollution, which is harmful for humans and ecosystems.[18] Other byproducts of coal can contribute to poor air quality and respiratory problems. Coal mines can release methane (a greenhouse gas) into the atmosphere and, once abandoned, can leak acidic water into the environment.[19] In order to reduce the amount of pollution emitted into the atmosphere, scientists are working to develop technology to capture pollution before it leaves the power plant.[20]


SOUTHWINGS

Mountaintop removal mining involves using explosives to remove land above coal deposits.

Nuclear

Nuclear energy refers to the energy stored within the nucleus of an atom. When atoms are split, a large amount of heat is released. This amount of energy is so great that it can heat water up to 520˚ Fahrenheit![21] Steam from this hot water can be used to turn turbines to generate electricity.

The primary fuel used for nuclear energy is uranium—a nonrenewable resource. Uranium can be found in rocks and extracted from surface or underground mines. Uranium can also be recovered from oceans. Once extracted, uranium is then processed into fuel for nuclear power plants that convert it into electricity. About 13.5% of the world's electricity is generated from nuclear energy and about 30 countries operate nuclear power plants.[22]

One main drawback of nuclear energy is the radiation given off by the process of nuclear fission and the nuclear waste generated by nuclear power plants. This waste will remain radioactive for thousands of years. There is no permanent disposal site for the highly radioactive waste in the United States and most of it is stored at nuclear power plants.[23] Radioactive materials are hazardous to human health. For example, four years after a 1986 nuclear accident at the Chernobyl nuclear power plant in Ukraine, the World Health Organization reported 5,000 cases of thyroid cancer in children ages 18 and younger.[24] Because radioactive materials are hazardous to human health, many


JEFFERSON S. ROGERS

The hot steam generated during nuclear fission is cooled using cooling towers.

people do not want a nuclear reactor or waste near their homes.

Another drawback to nuclear energy is that a lot of water is used to cool down the steam produced to generate electricity. This water can come from nearby lakes, rivers, or oceans. Due to the serious nature of the risks to the nearby environment and human health, nuclear power plants have many safety systems created to prevent accidents. The failure of these systems can be tragic. For example, in the wake of a 2011 earthquake and tsunami off the coast of Japan, the Fukushima nuclear power plant lost power. A couple small fires started and radioactive waste was released.[25] Due to the risk of radiation, over 100,000 people were evacuated from their homes.[26]

Despite the above concerns, there are many reasons why countries might turn to nuclear power as a source of electricity. Uranium has an incredibly high energy density; one ceramic pellet of uranium is about as big as your fingertip yet has about as much energy as 150 gallons of oil.[27] Although energy (usually from fossil fuels) is required to mine and refine uranium, nuclear fission is a way to produce electricity without creating greenhouse gases and other air pollutants.

Hydroelectric dams convert the kinetic energy of moving water into electricity.

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Renewables

Renewable energy resources are able to be replaced quickly and naturally. They include moving water, biomass, heat from Earth's core, and the sun.

Water

Have you ever river rafted or been caught in a rip tide just off the beach? If so, you know that water is powerful. Fast-flowing water, waterfalls, ocean tides, and waves all contain kinetic energy that can be harnessed to generate electricity. Fast-flowing water, waterfalls, ocean tides, and waves all contain kinetic energy that can be harnessed to generate electricity. Water (or hydroelectric) power refers to the kinetic energy of moving water. Because water is renewed naturally through the earth's water cycle, water power is considered a renewable energy source.

Most electricity generated from water relies on moving water to turn turbines that capture the water's kinetic energy. This can look different depending on the location and source of water. For example, tidal fences are vertical structures built in the oceans that are embedded with turbines. As the tides move in and out, the flowing water turns the turbines.[28] Hydroelectric power plants, on the other hand, are constructed near freshwater dams. Gates open to release water stored behind the dam so that water flows through turbines to generate electricity.[29]

Producing electricity from moving water does not result in significant carbon dioxide emissions or air pollution because no fuel is burned. However, hydroelectric power may result in some emissions from water reservoirs (bodies of water held by dams). Water is denser than air, so a turbine built for tides can capture more energy than wind. However, this can make the turbine more costly to build because it must be sturdy.[30]

Many countries around the world have built dams in order to generate hydroelectric power. China produces the most hydroelectricity in the world and has created the largest hydroelectric dam in existence.[31] The Three Gorges Dam was built on China's Yangtze River and produces about 85 Terawatthours (TWh) per year. Eighty-five TWh will meet a tenth of China's current annual electricity need.[32] Hydroelectric power plants provide some of the least expensive electricity to consumers and are about 90% efficient in converting the water's kinetic energy into electricity.[33]

However, building large dams can have high monetary, ecological, and social costs. Often people who live in the area must move to allow the flooding of land to create a reservoir. It is estimated that over 1.4 million people were displaced from their homes by the construction of the Three Gorges Dam.[34] In addition, sediments (soil, sand, and leaves) can build up in reservoirs, decay, and produce methane emissions.[35] That sediment reduces water quality for organisms that live in the water and can choke out the sun's light. Changing the path of a waterway affects any organisms dependent on that waterway. Migrating fish, such as salmon, may have trouble swimming around dams. Damming may also cause erosion along riverbanks.

In response to these ecological concerns, there have been some efforts to remove dams and restore rivers and their surrounding ecosystems to their natural state. For instance, the Elwha Dam in Washington State was removed in 2012 to help restore the river and fisheries.[36] There is also interest in creating smaller, low-cost hydropower technology that would cause less damage to the environment while still producing energy from a renewable resource.[37]

Biomass

Biomass, or bioenergy, is recently living organic material that can be used as a fuel source. In the process of photosynthesis, plants and organisms like algae capture sunlight and convert it to chemical energy. Humans have used wood (one type of biomass) for years to provide heat for their homes and cook their food. More recently, people have begun burning biomass to generate electricity as well as converting biomass into liquid fuels to run cars and trucks. Wood is still the most common form of biomass used today, but animal dung (waste), grasses, algae, corn, sugarcane, and even garbage or wood waste from construction can be used as fuel.[38]

TANZANIA/© 2003 SARAH BONES/CARE

Wood is the most common form of biomass used today.

Biomass is considered a renewable energy source because organic matter can be regrown relatively quickly. To accurately evaluate the sustainability of biomass, one would need to take a close look at each type of biomass and the way that it is harvested and grown.

Like fossil fuels, burning biomass directly or as transportation fuel produces carbon dioxide emissions. Unlike fossil fuels, the carbon dioxide released by burning biomass was recently absorbed from the atmosphere as part of the natural carbon cycle. If biomass is regrown, it can absorb carbon dioxide from the atmosphere and release oxygen. By contrast, burning fossil fuels releases carbon dioxide that has not been in the atmosphere for millions of years. However, if biomass is not replanted at the same rate that it is being used, the result could be increased carbon dioxide emissions and deforestation.

There are other downsides to biomass energy. Fertilizers and chemical pesticides that might be used to grow biomass are made from fossil fuels. Also, converting land once used to produce food into land that produces biomass for fuel can have negative global impacts on food supply and prices that would likely affect the people in our world that most need food.

YOUTH PROFILE

Whitney M. Young Magnet High School

Sophomore Anna Hernandez wanted to learn more about alternative and green energy technology for a science fair project. She found out about something called biodiesel, a type of fuel made by combining oil with ethanol or methanol. When used in farm machinery or other diesel engines, biodiesel produces fewer greenhouse gases than petroleum-based diesel.

With help from the University of Illinois at Chicago and teacher Brian Sievers, Anna Hernandez and four other students from Chicago's Whitney M. Young Magnet High School created a functional, full-sized biodiesel production system. They converted 1,460 gallons of cooking oil from neighborhood restaurants into biodiesel fuel. They donated biodiesel to farmers and others who use diesel engines.[39]

The students then built and donated a biodiesel system to Mendota High School, a school in rural Illinois, so they could share with the students there what they learned. "They were totally excited to get started making biodiesel," said Sabrina Kwan, a sophomore at Whitney Young. The project even crossed national borders when the students gave a presentation on how to make a biodiesel system to a company in Honduras!

Wind

Wind is produced because the sun heats the surface of the earth unevenly, causing air to circulate. This moving air is a renewable form of energy that can be converted into electricity. When wind turns the blades of a wind turbine, a generator inside the gearbox (at the top of the tower) converts the mechanical action into electricity. Cables inside the tower transmit this energy to a transformer where it is converted to a voltage appropriate for transmission to your home.[40]

The use of wind energy to produce electricity is increasing around the world.[41]

Whitney M. Young students converted used cooking oil into biodiesel.

PHOTO COURTESY OF JORDAN STALKER

The main benefit of using wind power is that once a wind farm is set up, it does not produce air or water pollution. There is also no need to buy fuel; wind is free. However, wind is an intermittent energy source. The wind does not always blow when people want electricity and the speed of wind cannot be controlled, reducing the reliability of electricity produced by wind.

With new smart grid technologies, however, this problem could be mitigated. An **electric grid** is made up of all of the equipment (i.e., transmission lines, transformers) necessary to transfer electricity from a power plant to a customer. A smart grid refers to an electric grid that has technology to allow the two-way communication of information about electricity production and consumption to flow between producers to consumers. This information can be used to increase the efficiency of our electricity system by helping consumers maximize their use of wind energy.[42] For example, smart grids used in the country of Denmark help citizens know when there is enough wind energy available to use appliances in their homes.[43]

Wind is not a universally popular source of energy. Wind turbines require large amounts of land and there may be competing interests for the use of this land, such as farming or cattle. Wind farm opponents claim that wind turbines ruin the landscape and cause noise pollution. Wind turbines can kill migrating birds and careful placement is needed to reduce this effect.

Offshore wind farms, or wind turbines located in bodies of water, are also gaining popularity around the world. While the United States has been slow to adopt wind turbines in oceans, there are 12 countries that have (90% of these are in Europe[44]). Opponents to offshore wind turbines in the United States are concerned about the view of the turbines from the shore. Yet according to the Earth Policy Institute, "Nine of the top 10 carbon dioxide emitting countries in 2010 have more than enough offshore wind energy potential to meet all their current electricity needs."[45]

NUALABUGEYE

The use of wind energy to produce electricity is increasing around the world.

Geothermal

One renewable form of energy that is not derived from the sun is geothermal energy. Geothermal energy comes from heat produced in the earth's core. This energy can be used to provide heat or generate electricity from steam produced by this heat. At least one quarter of electricity in the Philippines, Iceland, and El Salvador comes from geothermal energy.[46]

Earth contains an incredible amount of geothermal energy. The amount of heat that flows from the earth into the atmosphere each year is equal to 10 times the amount of energy that the United States uses each year.[47] This type of energy produces very few emissions (1-3% of the carbon dioxide and 3% of the acid rain produced by fossil fuels).[48]

electric grid—A system that distributes electricity from power plants to locations that use electricity; it includes power lines, power generators, transformers, and all of the homes and businesses that use electricity.

However, some pollution such as hydrogen sulfide (which can contribute to acid rain and smells like rotten eggs) can naturally occur in water heated by geothermal energy. Also, geothermal energy is not located everywhere and the cost of exploratory drilling and the initial setup of power plants can be high. Corrosion can also be a problem with geothermal energy.[49]

CASE STUDY Barefoot Solar Engineers[50]

Envision a college where young people, parents, and even grandparents—most of whom cannot read or write—are admitted to train to become solar engineers, water specialists, dentists, doctors, teachers, mechanics, architects, artisans, masons, computer programmers, and accountants.

This college doesn't require students to be literate. Rather, they require commitment to service. The school's philosophy is that through dedicated and rigorous apprenticeship anyone is capable of learning important trades such as installing solar lighting systems, providing basic dental care, and building housing. This is the Barefoot College in India and it serves students—young and old—from India, Asia, Africa and South America.


KIMBERLY CORRIGAN

Barefoot College trains people from impoverished rural areas to bring sustainable solutions such as solar electrification to their communities.

Barefoot College is a non governmental organization founded in 1972. Its purpose is to help impoverished rural communities become self-sufficient and sustainable. It seeks to halt the mass migration of unemployed people to overcrowded cities and urban slums, retaining them in their villages with meaningful work. Because the organization believes that successful development must be rooted and managed by the community, their approach is to listen to what communities need and then train through apprenticeship so that people return to their communities prepared to thrive and help others do the same.

The Barefoot College asserts—as did the world-renowned Indian leader of nonviolent civil disobedience Mahatma Gandhi—that the skills and wisdom of rural communities should be honored and used to foster lasting change, and that technology should be managed by the locals to prevent the community from becoming exploited or dependent on outside help. The college stresses the importance of demystifying new technologies and decentralizing their use, as well as promoting traditional knowledge and skills that have been employed successfully for millennia. Let's look at one example—bringing solar power to nonelectrified, rural villages.

The process begins with an interested community forming a Village Environmental Energy Committee. This committee communicates with villagers about solar power and will collect a small monthly payment from families participating in the subsidized program. The committee and community select individuals to attend a six-month, in-residence training program at Barefoot College's campus. The college often encourages communities to pick people who struggle to find employment such as single mothers or widows. Upon completion the "Barefoot Solar Engineers" return home, manage the project, and earn a monthly stipend.

At the Barefoot College the message is clear: being educated is about more than reading and writing, it's about caring for yourself, your community, and the world around you.

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Geothermal energy comes from the heat produced in Earth's core.

Solar

Solar energy comes directly from the earth's star, the sun. This energy can be harnessed passively or actively to heat homes and water or to generate electricity. For years, humans have been building homes and shelters to take advantage of the sun. For example, ancient Roman bathhouses were built facing south toward the sun. In the 1200s, the Anasazi people in North America sheltered themselves in south-facing cliff shelters in order to warm their environments.[51] Many homes today are still built to capture winter sun and deflect summer sun.

Like wind and water, sunlight is free and solar energy is a renewable resource. Photovoltaic cells, or solar cells, allow us to actively capture sunlight and convert it to electricity. Solar cells can be installed on people's homes to provide direct electricity for their needs. Any extra solar energy can be sent back to the city's electrical grid.

Manufacturing photovoltaic cells, however, requires energy, the extraction of resources, and the use of toxic chemicals that must be disposed of properly. Currently, solar cells are fairly inefficient and convert only about 11-27% of the sun's energy into electricity.[52]

Solar energy is also a diffuse form of energy and concentrating and storing it can be challenging.[53] Like wind, sunlight is not consistent or steady. Time of day, season, latitude, and cloudiness all impact the amount of solar energy available.[54] For example, a desert location can get over six kilowatt-hours per day per square meter, while a cloudy December day in Seattle can receive as little as 0.7 kilowatt-hours per day.[55]

CHECK FOR UNDERSTANDING

1. In general, what are some of the benefits and trade-offs of using nonrenewable energy sources? What are some of the benefits and trade-offs of using renewable energy sources?
2. How might geography or location affect the sustainability of a particular energy source?
3. How could a nation benefit from using a diversity of energy resources? Might there be any disadvantages to having a diverse fuel mix?

Reading 3

Background on Energy

For as long as humans have lived, acquiring food has been a top priority. We require a certain amount of calories (a unit that measures the amount of energy stored in food) in order to survive. Over time, humans also learned to harness energy resources for purposes beyond basic survival.[1]

One of the first advancements humans made in the field of energy was the utilization of fire. Thousands of years ago, humans learned to use fire to cook their food and provide heat for their bodies. Why would cooking food before eating it be beneficial? Not only can cooking food such as meat kill harmful bacteria, but it also makes the food more digestible.[2] This means that a person's body might be able to absorb more calories from the same source, providing more energy.

Other advancements helped early human societies become more efficient in producing food calories, particularly agriculture. For a long time, however, we relied on direct energy sources, using animals, wind and water for transportation and wood fire for cooking and heating.

Energy Powers a Revolution

By the 1500s, England was using wood energy not only to cook food, but also to fuel its industry. British ships were built from wood and sailed using wind energy. Wood was also burned for fuel to manufacture materials such as steel and iron.[3]

Eventually, the use of wood outpaced regeneration of forests and the English were faced with a wood shortage, known as the timber famine. Between 1500 and 1630, people in England witnessed a sevenfold increase in the price of wood.[4] Although wood was the preferred fuel for heating and manufacturing at the time, the shortage and rising price of wood forced many people to turn to coal for fuel.[5] Coal was used as an energy source for much of human history, often for smelting metals. This replacement of wood with coal not only solved Britain's wood fuel crisis—it revolutionized industry.[6]

As the English began to deplete coal found near the surface of the earth, they started to dig coal mines deeper and deeper. This caused water to seep through the walls of the mines and flood them. To solve this problem, the steam engine was invented to pump water out of the mines. Coincidentally, coal became the main fuel used for steam engines.

People soon developed many other uses for the steam engine; it was used to power machines in factories, move trains, and fuel ships. As a result, people could move around the world faster than ever and machines could perform the work that used to require the labor of hundreds of people or animals. In the early 1700s, producing one kilogram of yarn by hand

The steam engine was invented during the Industrial Revolution to pump water out of coal mines.

required 1,100 hours of labor. By the early 1800s, it took only three hours of labor.[7] The widespread use of the steam engine revolutionized industry and established coal as one of its primary sources of energy.

Meanwhile, scientists had been experimenting with electricity. An important advancement came in the early 1800s, when the British physicist Michael Faraday showed that electricity could flow in a metal wire influenced by a changing magnetic field. However, until Nikola Tesla (a Serbian immigrant to the United States and an innovative scientist, engineer, and inventor) demonstrated how to transmit this electricity over long distances in the 1880s, electricity was not a practical supply of energy.[8] **Electricity** is a secondary form of energy resulting from the existence of charged particles, meaning that another form of energy such as coal or wind must be used to produce it.

Petroleum Moves Us

In the mid-1900s, petroleum (or oil) replaced coal as the world's leading fuel source.[9] Humans had been using oil that seeped up to the surface of the earth for thousands of years as adhesives, lubricants, and even medicine. As early as 347 C.E., people in China were using bamboo poles to dig oil wells 800 feet deep.[10] Over time, several historical events created a larger market for petroleum. First came the discovery of kerosene, a fuel made from petroleum. In 1849, a Canadian geologist named Abraham Gesner discovered how to make kerosene for lamp fuel.[11] Kerosene replaced whale oil (oil made from whale blubber), which had been the main energy source for lighting

electricity—A form of energy generated by the movement of charged particles; generally produced as a secondary form of energy by converting other forms of energy (such as coal or wind) into electricity.

CASE STUDY The Oil Embargo of 1973

In 1973 on Yom Kippur, the holiest day of the year for the Jewish faith, Syria and Egypt attacked Israel in an effort to regain land taken by Israel during the 1967 war. In response, the United States decided to supply Israel with arms and the Soviet Union began supplying Egypt and Syria with arms. Arab members of Organization of the Petroleum Exporting Countries (OPEC) were against the U.S. decision to support Israel and announced an embargo, or ban, on trading oil with countries that supported Israel during the war.[12]

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The Oil Embargo of 1973 limited the supply of oil and gas in the United States.

The Oil Embargo of 1973 caused global oil prices to spike and limited the supply of oil for a short time. In the United States, this ban—which was characterized by high oil and gas prices and shortages at the pump—prompted the federal government and citizens to adopt ways to conserve energy.[13] Even after the embargo was lifted, the price of gasoline and heating oil remained high and may have contributed to an economic recession in 1974 and 1975.[14]

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Hiroshima, Japan experienced a nuclear bomb attack during World War II.

and whose supply was declining. In the early 20th century, the mass production of automobiles as well as the use of military transportation that ran on petroleum-based fuel helped to create a lasting market for oil products.

The Advent of Nuclear Energy

Beyond coal and oil, there have been significant advances in other sources of energy. Scientists knew at the beginning of the 1900s that atoms stored large amounts of energy. They learned that when an atom is split into smaller atoms (a process called **fission**), an incredible amount of heat and radiation is released. In the years leading up to World War II, scientists conducted research into nuclear energy with a focus on creating new weapons.[15]

On August 6, 1945, the United States dropped the first atomic bomb to ever be used in war on Hiroshima, Japan. Three days later the United States dropped a second bomb on Nagasaki, Japan. The official death toll from these bombs was over 200,000. Many of these deaths did not occur immediately; a large number of people died later from exposure to **radiation**.[16]

Approximately one year later, the U.S. government created the Atomic Energy Commission as an effort to encourage the development of peaceful uses of nuclear energy, primarily as an alternative to fossil fuels to produce electricity. Today several countries around the world use nuclear energy to generate electricity.[17]

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fission—The process of splitting an atom into smaller parts; this releases a large amount of energy and one or more neutrons.

radiation—A type of energy given off by nuclear fission that can damage cells, cause cancer, and may lead to death.

CHECK FOR UNDERSTANDING

1. How has the consumption of energy by humans changed over time?
2. What are some recurring themes in the history of energy use?
3. What are some factors that influenced a group of people to transition from one main energy source to another?
4. How did the Oil Embaro of 1973 affect people in the United States?

Reading 4

Pathways to Progress: Energy

Now that you have studied several different energy resources, what do you think are the most sustainable ways to supply our world's growing demand for energy? In other words, how do we make sure that all people have access to reliable forms of energy without compromising the health of the environment or the ability of future generations to meet their energy needs?

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Energy Conservation

Every choice about energy we make can make a difference in the amount of energy used and the pollution emitted. Perhaps the easiest and most practical way we can contribute to sustainable energy solutions is to simply use less energy. Behaviors and actions that save or use less energy—such as turning off the lights when you leave a room—are often referred to as **energy conservation**.

Individuals, communities, businesses, and governments all have the ability to address energy conservation. For example, the city of Grand Rapids, Michigan has created an inventory of electricity use for all city buildings in order to track usage and reduce energy consumption. The city has also made an effort to purchase 20% of its energy from renewable sources.[1]

Energy Efficiency

Another way to reduce our energy consumption is by using energy more efficiently. **Energy efficiency** refers to completing a specific task with less energy input than usual.[2] For example, an energy-efficient light bulb—such as an LED or CFL light bulb—requires less energy to produce the same amount of light as other light bulbs.

You may have seen technology and appliances such as light bulbs, computer monitors, or refrigerators that are labeled as energy efficient. One such label, ENERGY STAR®, was created by the U.S. Environmental Protection Agency and Department of Energy as a way for companies to let customers know about energy-efficient products and to encourage the reduction of greenhouse gases.[3] According to ENERGY STAR, if each American home replaced one light bulb with an energy-efficient light bulb we could collectively save $600 million in energy costs and prevent 9 million pounds of greenhouse gases from being released into our atmosphere each year.[4] Sometimes an energy-efficient product is more expensive to buy up front. However, it is often more cost-effective in the long term because you will save more money over time on your utility bills.

Policies and Subsidies

At the governmental level, policies can be passed that encourage sustainable energy practices. In response to the oil crisis of the 1970s, Corporate Average Fuel Economy (CAFE) standards were enacted in the United States in 1975. These standards required vehicle manufacturers to create passenger cars

energy conservation—Behaviors and actions that save or use less energy, such as turning off the lights when you leave a room.

energy efficiency—Completing a specific task with less energy input than usual, such as using an energy efficient LED light bulb which uses less energy than other light bulbs to produce the same amount of light.

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Energy-efficient appliances use less energy to perform the same tasks as other appliances.

CAREER PROFILE NGO Founder

Stacy Noland founded the nongovernmental organization, Moontown Foundation.

Do you think only governments tackle big social problems? Nongovernmental organizations (NGOs), can also work to address big problems for the benefit of society as a whole or for an underrepresented segment of society.

CEOs and founders of NGOs usually have both a bachelor's degree and business experience. They are savvy in communications, marketing, and management of personnel and finance.

Stacy Noland wants to see major change in the way society powers homes and the work force. After receiving a bachelor's degree in psychology and working as a manager at Microsoft, he founded the Moontown Foundation. The Moontown Foundation is an NGO that creates initiatives with a dual goal: to empower individuals through experiential education and to make immediate impact on climate change and environmental degradation in the communities that need it most. As Stacy states, "It's my personal mission to get the people in poverty to adopt energy conservation, healthy, sustainable living, and alternative transportation, first. Those are the hardest people to reach." The Foundation's YES Program (Young Ecopreneurs in Sustainability) and SWITCH Program are focused on creating careers in home energy efficiency and solar energy. They introduce young adults to the mechanics of energy-saving technologies including solar paneling, weatherizing, and low-flow shower heads. Other projects focus on working with entire communities and considering how to create sustainable solutions to problems. One of these is the Storm Surge project, a documentary film about bringing sustainability to the southeastern states. In the wake of Hurricane Katrina, the 2010 Gulf Oil Spill, and widespread natural disasters, the film looks at how sustainability can be crucial to the health of all states.

The creation of CAFE standards in the United States have ensured high fuel efficiency for cars sold domestically.

and light trucks with improved fuel efficiency (better gas mileage).[5] Today CAFE standards are 33.3 miles per gallon for cars (double that of 1974 vehicles) and 25.4 miles per gallon for light trucks.[6] In 2012, even higher efficiency standards were finalized; the goal is for U.S. vehicles to get an average gas mileage of 54.5 miles per gallon by 2025.[7]

Getting better gas mileage means that drivers will need less gas for each mile they drive. Not only can these regulations help drivers save money at the gas pump, but they can also reduce the amount of greenhouse gases emitted by cars. Japan, Canada, Australia, China, and the Republic of Korea have also created standards to improve car fuel economy and other countries are expected to join them.[8]

Government regulations, like those for fuel economy, are just one way that governments can influence how we use energy. Governments can also influence the types of energy we use through subsidies. An **energy subsidy** is an economic benefit provided by a government that reduces the cost of producing a particular energy resource, increases the price received for an energy resource, or reduces the cost of a good or service.[9] In 2010, global fossil fuel subsidies totaled around $409 billion and renewable energy subsidies totaled around $66 billion.[10] For example, the California Solar Initiative

energy subsidy—An economic benefit provided by a government that reduces the cost of producing a particular energy resource, increases the price received for an energy resource, or reduces the cost of a good or service.

CASE STUDY Students Conduct ECOoffice Audits[11]

ECOoffice is a community service learning activity for students who work directly with local businesses to conduct a basic carbon footprint analysis. From this analysis, youth prepare a report that includes results and recommendations of affordable, achievable actions the company can take to reduce energy consumption, save office resources and lower operating costs.

PHOTO COURTESY OF ECOAUDIT

These students conducted an ECOoffice audit of the Unilever Corporation offices in Shanghai.

ECOoffice is one component of the Jane Goodall Institute-Shanghai Roots & Shoots' Eco Audit Educational Program. The company brings together local businesses, college students, and high school students in a collaborative effort to promote environmentally responsible practices in the business environment.

In April 2009, a trained student group from Shanghai High School International Division conducted an ECOoffice audit of the Unilever Corporation offices in Shangai. Using a standardized ECOoffice Checklist as their evaluation guide for measuring the office's sustainable practices, the students conducted the audit which consists of three parts:

- walkthrough observations
- administrative interviews
- employee surveys

With Unilever-Shanghai and Shanghai Roots & Shoots support, the students submitted an audit report which contained positive and negative points about company operations and employee behaviors. The report included practical suggestions for improving the company's environmental impact.

After implementing the students' suggestions throughout the following year, the employees reduced their resource consumption and the company's operating costs. Unilever management realized the sustainable improvements brought by ECOoffice project also would benefit the company financially; therefore, they wished to bring green concepts to more employees.

A business professional from Seattle learned about the positive impacts ECOoffice had on the Shanghai business community and asked Shanghai Roots & Shoots if the program could be brought to the Seattle area. Since that time, 141 students have conducted 38 ECOoffice audits at various workplaces throughout Washington State impacting 2,698 employees. These workplaces included architectural and engineering firms, fire stations, restaurants and retail shops, a local YMCA and a few Washington State governmental offices. The auditors consisted of students of various ages and numbers: from small independent groups of one or two students, to curriculum programs at a college, three high schools and even a very small eighth grade class.

The ECOaudit Program was also brought to New Delhi, India; and is run as a program of the Indian Youth Climate Network (IYCN). Since then, 55 college students from New Delhi audited 13 companies impacting 1320 employees. Re-audits will be conducted beginning the fall of 2011.

WHAT YOU CAN DO

Each one of us has the ability to contribute positively to sustainable energy use. The list below suggests a few things that you can do to work toward sustainable energy use. You may even find that, after trying some of these things, there are benefits to these activities beyond a decrease in energy use:

- Commute by foot, bike, public transportation, or carpool.
- If you are shopping for a car, consider its fuel efficiency. By saving on gasoline, you will also save money.
- Perform an energy audit on your home or school.
- Get involved with global campaigns that work to ensure that all people have access to energy.
- Lobby state and national governments for higher energy-efficiency standards and investments in renewable energy.


KATE DAVISON, GREENPEACE SOUTHEAST ASIA

You can contribute in many ways to sustainable energy use.

(CSI) provides rebates for California consumers who purchase various types of solar energy.[11]

Government institutions can also take part in sustainable energy solutions. The U.S. Department of Defense—the largest consumer of energy in the nation—is promoting renewable and efficient energy use.[12] After several marines were killed while guarding a fleet of fuel trucks, military leaders suggested that reducing the military's reliance on fossil fuels would drastically improve its safety and capability.[13] One energy-saving idea put forth was to insulate military tents. Because temperatures are so high in the desert, a great deal of diesel is used for air conditioning in tents. In Iraq and Afghanistan, these simple measures, along with solar panels at interior bases, cut fossil fuel demand in half and saved the military $95 million in just six months![14] People have begun to refer to officers who promote and encourage the use of sustainable policies and supplies as Green Hawks.

CHECK FOR UNDERSTANDING

1. What is a personal way to address both energy conservation and energy efficiency?
2. How can a government subsidy support energy conservation?
3. What does Stacy Noland's program introduce young people to?
4. Where do you see opportunities for energy to play a role in environmental, social, and economic development?

Endnotes

INTRODUCTION

1 Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report; Summary for Policymakers,* November 2007, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

LESSON 1

1 U.N. Secretary-General's Advisory Group on Energy and Climate Change, *Energy for a Sustainable Future: Summary Report and Recommendations,* April 28, 2010, http://www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGECC%20summary%20report[1].pdf.

2 U.S. Department of Energy, "Lighting Choices to Save You Money," Energy.gov, July 30, 2012, http://energy.gov/energysaver/articles/lighting-choices-save-you-money.

3 U.S. Department of Energy, *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education* (Washington, DC: March 2012), http://www1.eere.energy.gov/education/energy_literacy.html.

4 Stephanie Chasteen and Rima Chaddha, "How Do Solar Panels Work?," NOVA beta, under Tech + Engineering, April 24, 2007, http://www.pbs.org/wgbh/nova/tech/how-solar-cell-works.html.

5 David JC MacKay, "Solar," in *Sustainable Energy—without the hot air,* accessed July 15, 2013, http://www.withouthotair.com/c6/page_38.shtml.

6 U.S. Department of Energy, "Photovoltaic Cell Conversion Efficiency," Energy Efficiency & Renewable Energy, under Energy Basics: Renewable Energy; Solar, accessed July 15, 2013, http://www.eere.energy.gov/basics/renewable_energy/pv_cell_conversion_efficiency.html.

7 The National Academies, "On the Road," What You Need to Know About Energy, under Understanding Efficiency, accessed July 15, 2013, http://needtoknow.nas.edu/energy/interactive/understanding-efficiency/.

8 U.S. Department of Energy and U.S. Environmental Protection Agency, "Fuel Economy: Where the Energy Goes," fueleconomy.gov, last modified July 15, 2013, http://www.fueleconomy.gov/feg/atv.shtml.

9 The National Energy Education Development (NEED) Project, *Exploring Hydroelectricity: Student Guide 2012- 2013,* accessed July 15, 2013, http://www.need.org/needpdf/Exploring%20Hydroelectricity%20Student.pdf.

10 Sam Shelton, "Electric Power Plant Characteristics," *Energy 101: Week 7 Electric Power Technologies* (Coursera Course), accessed April 2, 2013.

11 Sunita Satyapal, "Calling All Fuel Cells," Energy.gov, December 7, 2012, http://energy.gov/articles/calling-all-fuel-cells.

12 U.S. Department of Energy, "Fuel Cell Vehicles," fueleconomy.gov, last modified July 15, 2013, http://www.fueleconomy.gov/feg/fuelcell.shtml.

13 U.S. Department of Energy, "Fuel Cells," *Fuel Cell Technologies Program,* November 2010, http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/fct_h2_fuelcell_factsheet.pdf.

LESSON 2

1 The National Energy Education Development (NEED) Project, *Energy Infobooks* (for Intermediate and Secondary), accessed September 5, 2013, http://www.need.org/Energy-Infobooks; U.S. Energy Information Administration, "Energy Sources," Energy Kids, accessed September 5, 2013, http://www.eia.gov/kids/energy.cfm?page=2.

LESSON 3

1 Jan DeWaters, Basil Qaqish, Mary Graham & Susan Powers, "Designing an Energy Literacy Questionnaire for Middle and High School Youth," *Journal of Environmental Education* 4, no. 1 (2013): 56-78.

2 U.S. Environmental Protection Agency, "Energy," *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011,* accessed July 15, 2013, http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Chapter-3-Energy.pdf.

3 "Fun Facts," ENERGY STAR Kids, accessed July 15, 2013, http://www.energystar.gov/index.cfm?c=kids.kids_index&s=f.

4 The National Energy Education Development (NEED) Project, "Electricity," *Intermediate Energy Infobook,* 2012, http://www.need.org/needpdf/infobook_activities/IntInfo/Elec1I.pdf.

5 "Power play," ConsumerReports.org, accessed April 24, 2013, http://www.consumerreports.org/cro/resources/images/video/wattage_calculator/wattage_calclulator.html; U.S. Department of Energy, "Estimating Appliance and Home Electronic Energy Use,"Energy.gov, August 31, 2012, http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use.

6 John Herrman, "Is Your Smartphone Charger An Energy Hog?," *Popular Mechanics,* February 23, 2012, http://www.popularmechanics.com/technology/how-to/tips/is-charging-a-smart-phone-inflating-your-power-bill.

7 "Power Usage in Games," hardcoreware.net, accessed April 24, 2013, http://www.hardcoreware.net/reviews/review-356-2.htm.

8 "Electric Power Monthly," U.S. Energy Information Administration, under Electricity, accessed April 24, 2013, http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_03.

9 "British Thermal Units (Btu)," U.S. Energy Information Administration, under Energy Explained: Units and Calculators, last modified April 23, 2012, http://www.eia.gov/energyexplained/index.cfm?page=about_btu.

LESSON 4

1 California Energy Commission, "Fossil Fuels—Coal, Oil and Natural Gas," *The Energy Story,* accessed July 15, 2013, http://energyquest.ca.gov/story/chapter08.html.

2 U.S. Energy Information Administration, "Nonrenewable: Oil (petroleum)," Energy Kids, accessed July 15, 2013, http://www.eia.gov/kids/energy.cfm?page=oil_home-basics.

3 "How much oil does the United States consume per year?," U.S. Energy Information Administration, under Frequently Asked Questions, last updated November 15, 2012, http://www.eia.gov/tools/faqs/faq.cfm?id=33&t=6.

4 "Petroleum Facts," Energy101.org, accessed July1 5, 2013, http://www.energy-101.org/did-you-know/non-renewable-energy/petroleum-facts.

5 "Asia is the world's largest petroleum consumer," U.S. Energy Information Administration, under Today in Energy, February 24, 2012, http://www.eia.gov/todayinenergy/detail.cfm?id=5130.

6 Jimmy Carter, "Proposed Energy Policy," April 18, 1977, accessed at http://www.pbs.org/wgbh/americanexperience/features/primary-resources/carter-energy/.

7 "Timeline: Oil Dependence and U.S. Foreign Policy," Council on Foreign Relations, under Publications: Interactives, accessed July 15, 2013, http://www.cfr.org/energyenvironment/timeline-oil-dependence-us-foreign-policy/p24322.

LESSON 5

1 Manzoor Alam, Jayant Sathaye, and Doug Barnes, "Urban household energy use in India: efficiency and policy implications," *Energy Policy,* no. 11 (September 1998): 885-891, http://www.sciencedirect.com/science/article/B6V2W-3VSPDT5-5/2/4e92f1ba6c36ebf5598699807d7843e0.
2 Puneet Pal Singh, "India's energy crisis threatens its economic growth," *BBC News,* July 31, 2012, http://www.bbc.co.uk/news/business-19059213.
3 Humphrey Liloba, "Kenya: Donors Eye Kenya Energy Sector," *East African Business Week,* October 8, 2012, http://allafrica.com/stories/201210081242.html.
4 Oxfam GB Kenya Programme, Urban Poverty and Vulnerability in Kenya, September 2009, http://www.irinnews.org/pdf/Urban_Poverty_and_Vulnerability_in_Kenya.pdf.
5 Abjata Khalif, "Rural Kenyan energy project lights up job market, incomes," *Thomson Reuters Foundation,* March 17, 2011, http://www.trust.org/item/?map=rural-kenyan-energy-project-lights-up-job-market-incomes.
6 Clar Ni Chonghaile, "Kenya to host sub-Saharan Africa's largest windfarm," Guardian, March 28, 2012 http://www.guardian.co.uk/global-development/2012/mar/28/kenya-to-host-largest-windfarm-turkana.
7 "Russia," U.S. Energy Information Administration, under Countries, updated February 12, 2013, http://www.eia.gov/countries/country-data.cfm?fips=RS.
8 Sally McGrane, "'Active House' Upends Russian Energy Habits," *New York Times*, October 28, 2011, http://green.blogs.nytimes.com/2011/10/28/active-house-upends-russian-energy-habits/.
9 Ibid.
10 U.S. Energy Information Administration, "In Homes," Energy Kids, under Using and Saving Energy, accessed July 15, 2013, http://www.eia.gov/kids/energy.cfm?page=us_energy_homes-basics.
11 New America Foundation, "Trapped in the Middle," Energy Trap, accessed July 15, 2013, http://stories.energytrap.org/middleclass.
12 "Energy Use In Homes," U.S. Energy Information Administration, under Energy Explained: Use of Energy; In Homes, last updated February 5, 2013, http://www.eia.gov/energyexplained/index.cfm?page=us_energy_homes; "Overview: Quick Facts," U.S. Energy Information Administration, under Geography: U.S. States; Alaska, last updated July 2012, http://www.eia.gov/state/?sid=AK.
13 "What is the smart grid?," Smartgrid.gov, accessed July 17, 2013, http://www.smartgrid.gov/the_smart_grid.
14 Litos Strategic Communication, "The Smart Grid: An Introduction," prepared for the U.S. Department of Energy, accessed July 17, 2013, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf.
15 Ibid.
16 "About Us," Sustainable Energy For All (UN Initiative), accessed July 17, 2013, http://www.sustainableenergyforall.org/about-us.
17 "Indoor air pollution and health," World Health Organization, under Media Centre, September 2011, http://www.who.int/mediacentre/factsheets/fs292/en/index.html.
18 "Universal access to modern energy for the poor," United Nations Development Programme, accessed Aug. 27, 2012, http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/focus_areas/sustainable-energy/universal-access/.
19 Ibid.
20 "Objectives," Sustainable Energy For All (UN Initiative), accessed August 14, 2013, http://www.sustainableenergyforall.org/objectives.

LESSON 6

1 U.S. Department of Energy, "Table 1. Overall Average Fuel Prices," *Clean Cities Alternative Fuel Price Report: July 2012*, accessed August 5, 2012, http://www.afdc.energy.gov/uploads/publication/afpr_jul_12.pdf.
2 U.S. Department of Energy, "Table 2. July 2012 Overall Average Fuel Prices on Energy-Equivalent Basis," *Clean Cities Alternative Fuel Price Report: July 2012,* accessed August 5, 2012, http://www.afdc.energy.gov/uploads/publication/afpr_jul_12.pdf.
3 U.S. Department of Energy, "Alternative Fueling Station Locator," Energy Efficiency & Renewable Energy, under Alternative Fuels Data Center, accessed September 11, 2012, http://www.afdc.energy.gov/locator/stations/.
4 Ryan Villarreal, "Deadly Ethanol: Brazil's Sugarcane Farms Take Toll On Indigenous People," *International Business Times,* September 8, 2012, http://www.ibtimes.com/deadly-ethanol-brazils-sugarcane-farms-take-toll-indigenous-people-912116.
5 "Brazilian Transportation Fleet," SugarCane.org, under The Brazilian Model, accessed September 5, 2013, http://sugarcane.org/the-brazilian-experience/brazilian-transportation-fleet.
6 Ibid.
7 Edmar Fagundes de Almeida, Jose Vitor Bomtempo, and Carla Maria de Souza e Silva, "The Performance of Brazilian Biofuels: An Economic, Environmental and Social Analysis," (Discussion Paper No. 2007-5, Rio de Janeiro, Brazil, December 2007), http://www.internationaltransportforum.org/jtrc/discussionpapers/DiscussionPaper5.pdf.
8 Maria Luisa Mendonça, "Brazil: Sugar cane plantations devastate vital Cerrado region," *Pacific Ecologist* 17 (Summer 2009), http://www.pacificecologist.org/archive/17/pe17-brazil-sugar-cane-devastation.pdf.
9 Oak Ridge National Laboratory, "Biofuels and Agriculture: A Factsheet for Farmers," *Biofuels For Sustainable Transportation,* September 2001, http://plbrgen.cals.cornell.edu/cals/pbg/programs/departmental/forage/upload/Biofuels-and-Agriculture-a-factsheet-for-farmers.pdf.
10 C. Ford Runge, "The Case Against Biofuels: Probing Ethanol's Hidden Costs," *Yale Environment 360,* March 11, 2010, http://e360.yale.edu/feature/the_case_against_biofuels_probing_ethanols_hidden_costs/2251/.
11 Paul Holtberg, "EPACT2005 Summary," U.S. Energy Information Administration, under Forecasts & Analysis: Annual Energy Outlook Analyses, accessed September 5, 2013, http://www.eia.gov/oiaf/aeo/otheranalysis/aeo_2006analysispapers/epa2005_summary.html.
12 C. Ford Runge, "The Case Against Biofuels: Probing Ethanol's Hidden Costs," *Yale Environment 360,* March 11, 2010, http://e360.yale.edu/feature/the_case_against_biofuels_probing_ethanols_hidden_costs/2251/.
13 Timothy Wise, "The Cost to Mexico of U.S. Corn Ethanol Expansion," (*Global Development and Environment Institute Working Paper,* Medford, MA, May 2012), http://www.ase.tufts.edu/gdae/Pubs/wp/12-01WiseBiofuels.pdf.
14 "Ethanol Production and Distribution," U.S. Energy Information Administration, under Alternative Fuels Data Center: Fuels and Vehicles, last updated September 5, 2013, http://www.afdc.energy.gov/fuels/ethanol_production.html.
15 Erin R. Pierce, "Energy 101: Biofuels," Energy.gov, July 25, 2012, http://energy.gov/articles/energy-101-biofuels.
16 Bird Life International et al., "Woody Biomass for Energy: NGO Concerns and Recommendations," (April 2011), http://www.fern.org/sites/fern.org/files/NGO%20Report%20on%20Biomass%2011%20April%202011.pdf.

17 Lido Vizzutti ,"Confederated Salish and Kootenai Tribes Partner on Biofuel Research," *Flathead Beacon,* February 13, 2013, http://www.flatheadbeacon.com/articles/article/confederated_salish_and_kootenai_tribes_partner_on_biofuel_research/31831.
18 Bruce Dorminey, "Flying on Woody Biomass and Camelina: Consortium Seeks Biofuel Answers," RenewableEnergyWorld.com, August 21, 2012, http://www.renewableenergyworld.com/rea/news/article/2012/08/flying-on-woody-biomass-and-camelina-consortium-seeks-biofuel-answers.

PERFORMANCE-BASED ASSESSMENT
1 Adapted from Washington State Office of Superintendent of Public Instruction's *Middle School—Humans & the Environment CBA Rubric,* July 2008, http://www.k12.wa.us/SocialStudies/Assessments/MiddleSchool/MiddleSchGeo-HumansandTheEnvironment-CBA.pdf.
2 Adapted from George Mason University's *Development of Critical Thinking Rubric,* June 2010, http://ctac.gmu.edu/documents/10-CT%20rubric%208-5.pdf.
3 Ibid.
4 Adapted from Washington State Office of Superintendent of Public Instruction's *Middle School—Humans & the Environment CBA Rubric,* July 2008, http://www.k12.wa.us/SocialStudies/Assessments/MiddleSchool/MiddleSchGeo-HumansandTheEnvironment-CBA.pdf.

LESSON 8
1 "First Generation Biofuels," Biofuel.org.uk, accessed June 18, 2013, http://biofuel.org.uk/first-generation-biofuel.html.
2 "Second Generation Biofuels," Biofuel.org.uk, accessed June 18, 2013, http://biofuel.org.uk/second-generation-biofuels.html.
3 Clifford Krauss, "As Ethanol Takes Its First Steps, Congress Proposes a Giant Leap," *New York Times*, December 18, 2007, http://www.nytimes.com/2007/12/18/washington/ 18ethanol.html?pagewanted=all.
4 Stephanie Holmes, "Bioenergy: Fuelling the food crisis?," *BBC News,* June 4, 2008, http://news.bbc.co.uk/2/hi/europe/7435439.stm.
5 Bob Dinneen, "Is Ethanol a Solution, or a Problem?," *New York Times* (Letter to the Editor), June 27, 2011, http://www.nytimes.com/2011/07/04/opinion/l04ethanol.html.
6 Rudy Ruitenberg, "Corn Prices Rise Worldwide Due to U.S. Ethanol Policy, FAO Says," *Bloomberg,* January 21, 2012, http://www.bloomberg.com/news/2012-01-21/use-of-corn-for-fuel-in-u-s-is-increasing-prices-globally-fao-chief-says.html.
7 Matt Daily, "Oil, biofuel companies evolve into uneasy 'fren-emies'," *Reuters,* April 4, 2012, http://www.reuters.com/article/2012/04/04/us-biofuels-idUSBRE8331FH20120404.
8 Unless otherwise noted, information for this fact sheet comes from: Ross Macfarlane, Patrick Mazza, and Jeannette Allan, *Sustainable Aviation Fuels Northwest: Powering the Next Generation of Flight* (2011 Report), http://www.safnw.com/sustainable-aviations-fuels-bibliography/.
9 "Algae Research: Introduction," Smithsonian National Museum of Natural History, under Research & Collections: Botany; Research, accessed September 5, 2013, http://botany.si.edu/projects/algae/introduction.htm.
10 U.S. Department of Energy, *National Algal Biofuels Technology Roadmap,* May 2010, http://www1.eere.energy.gov/biomass/pdfs/algal_biofuels_roadmap.pdf.
11 Unless otherwise noted, information for this fact sheet comes from: Ross Macfarlane, Patrick Mazza, and Jeannette Allan, *Sustainable Aviation Fuels Northwest: Powering the Next Generation of Flight* (2011 Report), http://www.safnw.com/sustainable-aviations-fuels-bibliography/.
12 B.R. Stefansson, "Oilseed Crops," The Canadian Encyclopedia, accessed September 5, 2013, http://www.thecanadianencyclopedia.com/articles/oilseed-crops.
13 Unless otherwise noted, information for this fact sheet comes from: Ross Macfarlane, Patrick Mazza, and Jeannette Allan, *Sustainable Aviation Fuels Northwest: Powering the Next Generation of Flight* (2011 Report), http://www.safnw.com/sustainable-aviations-fuels-bibliography/.
14 "Municipal Solid Waste," U.S. Environmental Protection Agency, under Waste: Non-Hazardous Waste, last modified November 15, 2012, http://www.epa.gov/epawaste/nonhaz/municipal/index.htm.
15 "Industrial Waste," U.S. Environmental Protection Agency, under Waste: Non-Hazardous Waste, last modified November 19, 2012, http://www.epa.gov/osw/nonhaz/industrial/.
16 Unless otherwise noted, information for this fact sheet comes from: Ross Macfarlane, Patrick Mazza, and Jeannette Allan, *Sustainable Aviation Fuels Northwest: Powering the Next Generation of Flight* (2011 Report), http://www.safnw.com/sustainable-aviations-fuels-bibliography/.
17 Eleanor K. Sommer, ed., "Handout 2 Woody Biomass Basics," in *Woody Biomass Desk Guide & Toolkit* (National Association of Conservation Districts), accessed March 27, 2013, http://www.nacdnet.org/resources/guides/biomass/pdfs/handout_2.pdf.
18 "Feedstocks," Northwest Advanced Renewables Alliance (NARA), accessed September 5, 2013, http://nararenewables.org/groups/feedstock.

LESSON 9
1 Alison Milosfsky, ed., "Lesson 2.4: Identifying Your Conflict Style," *Peacebuilding Toolkit for Educators* (High School Ed.) (Washington, D.C.: Endowment of the United States Institute for Peace Press, 2011), http://www.buildingpeace.org/sites/usip.qorvisdev.com/files/GPC_EducatorToolkit-(HighSchool)_combined.pdf.
2 "About Us," Boeing website, last updated January 2013, http://www.boeing.com/boeing/companyoffices/aboutus/index.page?.
3 "How much fuel does an international plane use for a trip," How Stuff Works, accessed April 25, 2013, http://science.howstuffworks.com/transport/flight/modern/question192.htm.
4 "Air travel and climate change," David Suzuki Foundation, accessed April 25, 2013, http://www.davidsuzuki.org/issues/climate-change/science/climate-change-basics/air-travel-and-climate-change/.
5 "Facts and Figures," Air Transport Action Group, accessed September 5, 2013, http://www.atag.org/facts-and-figures.html.
6 "Pioneering Environmental Technologies: Sustainable Biofuels," Boeing, accessed September 5, 2013, http://www.boeing.com/aboutus/environment/environment_report_11/3_biofuels_pg_2.html.
7 "A 'Bio'Ride in the Sky," Northwest Advanced Renewables Alliance (NARA), accessed September 5, 2013, http://www.nararenewables.org/news/features/jetfuel.
8 Angel Gonzalez, "To go green in jet fuel, Boeing looks at algae," *Seattle Times,* August 30, 2007, http://seattletimes.com/html/businesstechnology/2003858756_boeingenergy30.html.
9 Ibid.
10 Debbie Hammel, *Aviation Biofuels Sustainability Survey,* (NRDC Issue Brief, March 2013) (IB: 13-03-a), http://www.nrdc.org/energy/aviation-biofuel-sustainability-survey/files/aviation-biofuel-sustainability-survey-IB.pdf.
11 Elisabeth Rosenthal, "Your Biggest Carbon Sin May Be Air Travel," *New York Times*, January 26, 2013, http://www.nytimes.com/2013/01/27/sunday-review/the-biggest-carbon-sin-air-travel.html?_r=0.

12 Jason Motlagh, "In Indonesia and Malaysia, as demand for palm oil grows, so do environmental, labor concerns," *Washington Post,* November 26, 2012, http://www.washingtonpost.com/world/asia_pacific/2012/11/25/857010fa-3036-11e2-a30e-5ca76eeec857_story.html?hpid=z10.
13 Julia Whitty, "My Heart-Stopping Ride Aboard the Navy's Great Green Fleet," *Mother Jones,* March/April 2013, http://www.motherjones.com/environment/2013/02/navy-climate-change-great-green-fleet.
14 "The History of Shell Oil Company," Shell Oil, accessed September 5, 2013, http://www.shell.us/aboutshell/who-we-are-2013/history.html.
15 "Congress Authorizes Oil Spill Prevention, Fishing Vessel Safety Upgrades," *Environment News Service,* October 4, 2010, http://www.ens-newswire.com/ens/oct2010/2010-10-04-092.html.
16 "Energy Facts," Western States Petroleum Association, accessed February 4, 2011, http://www.wspa.org/.
17 "Renewable Fuel Standard (RFS)," U.S. Environmental Protection Agency, under Transportation & Air Quality: Fuels & Fuel Additives, last updated August 8, 2013, http://www.epa.gov/otaq/fuels/renewablefuels/index.htm.
18 Ben Elgin and Peter Waldman, "Oil companies back out of biofuel work," *San Francisco Chronicle,* April 22, 2013, http://www.sfchronicle.com/business/article/Oil-companies-back-out-of-biofuel-work-4451744.php.
19 Clifford Krauss, "Big Oil Warms to Ethanol and Biofuel companies," *New York Times*, May 26, 2009, http://www.nytimes.com/2009/05/27/business/energy-environment/27biofuels.html?pagewanted=all&_r=0.
20 Ibid.
21 CERT website, accessed July 17, 2013, http://www.certredearth.com/.
22 "Council of Energy Resource Tribes Enters $3 Billion Biofuels and Bioenergy Agreement," *Indian Country Today Media Network,* September 25, 2012, http://indiancountrytodaymedianetwork.com/article/council-of-energy-resource-tribes-enters-%243-billion-biofuels-and-bioenergy-agreement-135584.
23 "Northwest Tribes Share Expertise," Northwest Advanced Renewables Alliance (NARA), under News and Features, accessed May 3, 2013, http://www.nararenewables.org/news/features/tribal.
24 Ibid.
25 Alice Miller, "Tribal forest biomass could become jet fuel," *Lake County Leader,* March 20, 2013, http://leaderadvertiser.com/news/article_22f2d800-91a1-11e2-98f2-0019bb2963f4.html.
26 "Council of Energy Resource Tribes Enters $3 Billion Biofuels and Bioenergy Agreement."
27 Ibid.
28 "Landscape planning on a large scale: Confederated Salish and Kootenai Tribes partner with NARA," *NARA Renewables,* (Newsletter, February 2013), http://www.nararenewables.org/feature/newsletter-3.
29 "Northwest Tribes Share Expertise."
30 John Daly, "U.S. Military Gets Serious About Biofuels," Oilprice.com, March 26, 2012, http://oilprice.com/Alternative-Energy/Biofuels/U.S.-Military-gets-Serious-about-Biofuels.html; Moshe Schwartz, Katherine Blakely, and Ronald O'Rourke, *Department of Defense Energy Initiatives: Background and Issues for Congress,* (Congressional Research Service Report for Congress, December 10, 2012), http://www.fas.org/sgp/crs/natsec/R42558.pdf.
31 Will Rogers "The Big Military Biofuels Build-Up: will it happen, and how, and why?," Biofuels Digest, December 13, 2012 (originally published in *Consumer Energy Report*), http://www.biofuelsdigest.com/bdigest/2012/12/13/the-big-military-biofuels-build-up-will-it-happen-and-how-and-why/.
32 Ibid.
33 Ibid.
34 Larry Abramson "Military's Green Energy Criticized By Congress," *National Public Radio* (NPR), under News: U.S.; National Security, July 5, 2012, http://www.npr.org/2012/07/05/156325905/militarys-green-energy-criticized-by-congress.
35 Will Rogers, "The Big Military Biofuels Build-Up."
36 USDA Office of Communications, "Release No. 0070.13," press release, April 15, 2013, http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2013/04/0070.xml&printable=true&contentidonly=true.
37 Council of Economic Advisors, "Strengthening the Rural Economy," The White House, under The Administration: Council of Economic Advisers, April 27, 2010, http://www.whitehouse.gov/administration/eop/cea/factsheets-reports/strengthening-the-rural-economy/the-current-state-of-rural-america.
38 Council of Economic Advisors, "Strengthening the Rural Economy."
39 USDA Office of Communications, "Release No. 0070.13," press release, April 15, 2013, http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2013/04/0070.xml&printable=true&contentidonly=true.
40 "Rural Development Energy Programs," USDA Rural Development, under Browse By Subject: Energy, last modified March 28, 2013, http://www.rurdev.usda.gov/Energy.html.

PRE AND POST ASSESSMENT

1 "Brazil," U.S. Energy Information Administration, under Countries, last updated February 28, 2012, http://www.eia.gov/countries/country-data.cfm?fips=BR.
2 "Stakeholder Meeting Chidamparaparuam Village 17th February 2008 for The Converging World Windfarm proposal Tamil Nadu," accessed June 13, 2013, http://www.carbonresource.com/pdf/Gold_Standard/14report.pdf.
3 U.N. Secretary-General, "Secretary-General to Global Development Center: 'Energy is the Golden Thread' connecting economic growth, social equity, environmental sustainability," press release, April 20, 2012, http://www.un.org/News/Press/docs/2012/sgsm14242.doc.htm.
4 Jan DeWaters, Basil Qaqish, Mary Graham & Susan Powers, "Designing an Energy Literacy Questionnaire for Middle and High School Youth," *Journal of Environmental Education* 4, no. 1 (2013): 56-78.
5 Ibid.

READING 1

1 Saumya Vaishampayan, "Anatomy of a Blackout: August 14, 2003," *Boston Globe,* February 3, 2012, http://articles.boston.com/2012-02-05/magazine/31020073_1_blackout-high-voltage-lines-power-plant.
2 David Barstow, "The Blackout of 2003: New York City; In Frustration, Humor and Greed, A Powerless New York Endures," *New York Times*, August 15, 2003, http://www.nytimes.com/2003/08/15/nyregion/blackout-2003-new-york-city-frustration-humor-greed-powerless-new-york-endures.html?pagewanted=all&src=pm.
3 Vaishampayan, "Anatomy of a Blackout."
4 "Fuel Economy: Where Energy Goes," U.S. Department of Energy (DOE), accessed May 25, 2012, http://www.fueleconomy.gov/feg/atv.shtml.
5 The National Energy Education Development (NEED) Project, "Electricity," *Secondary Energy Infobook,* 2012, http://www.need.org/Energy-Infobooks.

6 American Association for the Advancement of Science, “The Designed World,” *Science for all Americans* (New York: Oxford University Press, 1990).
7 “How We Use Energy,” National Academy of Sciences, under What You Need To Know About Energy, 2009, http://needtoknow.nas.edu/energy/energy-use/.
8 S. Kalyana Ramanathan, “India to Top in Car Volumes by 2050,” *Rediff India Abroad,* October 23, 2004, http://www.rediff.com/money/2004/oct/23car.htm.
9 Ban Ki-moon, “Sustainable Energy for All,” *Vision Statement by the Secretary-General of the United Nations,* November 2011, http://www.un.org/wcm/webdav/site/sustainableenergyforall/shared/Documents/SG_Sustainable_Energy_for_All_vision_final_clean.pdf.
10 Ibid.
11 International Energy Agency, “Energy Poverty: How to make modern energy access universal?,” early excerpt of *World Energy Outlook 2010 for the UN General Assembly on the Millennium Development Goals,* September 2010, http://www.un-energy.org/sites/default/files/share/une/energy_poverty_excerpt_weo2010.pdf.
12 Ibid.
13 “Sources of Greenhouse Gas Emissions,” U.S. Environmental Protection Agency, under Climate Change: Emissions; Sources, last updated July 30, 2013, http://www.epa.gov/climatechange/ghgemissions/sources/industry.html.
14 Alison Rae, *Oil, Plastics, and Power* (Mankato, MN: Smart Apple Media, 2010).
15 Ibid.
16 “Chemical measurements confirm official estimate of Gulf oil spill rate: New NOAA-led analysis shows gases and oil in three chemically different mixtures deep underwater, in the surface slick, in the air,” National Oceanic and Atmospheric Administration, January 9, 2012, http://www.noaanews.noaa.gov/stories2012/20120109_dwhflowrate.html.
17 “Saving Lives with Solar-Powered Lights,” *CNN,* under CNN Heroes, February 12, 2010, http://www.cnn.com/2010/LIVING/02/11/cnnheroes.wadongo/.
18 “Benefits,” Just 1 Lamp, accessed September 5, 2013, http://www.justonelamp.com/benefits/.

READING 2

1 “2011 in review,” British Petroleum (BP) Global, under Reports and Publications: Statistical Review of World Energy 2012, accessed December 5, 2012, http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481.
2 Alison Rae, *Oil, Plastics, and Power* (Mankato, MN: Smart Apple Media, 2010).
3 BP, *BP Statistical Review of World Energy June 2012* (London, 2012), http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2011/STAGING/local_assets/pdf/statistical_review_of_world_energy_full_report_2012.pdf.
4 “Peak Oil Primer,” Post Carbon Institute, under Energy Bulletin, accessed June 8, 2012, http://www.energybulletin.net/primer.php.
5 “How Natural Gas Works,” Union of Concerned Scientists, under Clean Energy, accessed November 29, 2012, http://www.ucsusa.org/clean_energy/technology_and_impacts/energy_technologies/how-natural-gas-works.html.
6 The NEED Project, “Natural Gas,” *Secondary Energy Infobook,* 2012, http://www.need.org/Energy-Infobooks.
7 Dawn Anderson, “Natural Gas,” Environmental Literacy Council, accessed June 11, 2012, http://www.enviroliteracy.org/article.php/68.html.
8 The NEED Project, “Natural Gas.”
9 “About U.S. Natural Gas Pipelines—Transporting Natural Gas,” U.S. Energy Information Administration (EIA), June 2007, http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html.
10 Rae, *Oil, Plastics, and Power.*
11 Ibid.
12 “What is shale gas and why is it important?,” EIA, under Energy in Brief, accessed November 29, 2012, http://www.eia.gov/energy_in_brief/about_shale_gas.cfm.
13 World Energy Council, *2010 Survey of Energy Resources,* 2010, http://www.worldenergy.org/documents/ser_2010_report_1.pdf.
14 Ibid.
15 EIA, “Coal,” Energy Kids, under Energy Source: Nonrenewable, accessed June 12, 2012, http://www.eia.gov/kids/energy.cfm?page=coal_home.
16 Ibid.
17 Rob Perks, “Time to End Mountaintop Removal Coal Mining,” National Resources Defense Council (NRDC), accessed April 22, 2012.
18 “How Coal Works,” Union of Concerned Scientists, under Clean Energy, last revised December 15, 2009, http://www.ucsusa.org/clean_energy/technology_and_impacts/energy_technologies/how-coal-works.html.
19 EIA, “Coal.”
20 Ibid.
21 “How Nuclear Power Works,” Union of Concerned Scientists, under Nuclear Power, last revised February 11, 2003, http://www.ucsusa.org/nuclear_power/nuclear_power_technology/how-nuclear-power-works.html.
22 “Nuclear Power in the World Today,” World Nuclear Association, accessed May 31, 2012, http://www.world-nuclear.org/info/inf01.html.
23 EIA, “Uranium (nuclear),” Energy Kids, under Energy Sources: Nonrenewable, accessed June 10, 2012, http://www.eia.gov/kids/energy.cfm?page=nuclear_home-basics.
24 Frank Qian, Effects of Nuclear Power on Public Health: From Three Mile Island to Fukushima,” Triple Helix Online, August 2, 2011, http://triplehelixblog.com/2011/08/effects-of-nuclear-power-on-public-health-from-three-mile-island-to-fukushima/.
25 Edwin Lyman, *Statement to the Senate Environment and Public Works Committee,* March 16, 2011, http://www.ucsusa.org/assets/documents/nuclear_power/lyman-senate-epw-3-16-11.pdf.
26 “Fukushima Accident 2011,” World Nuclear Association, updated November 2012, http://www.world-nuclear.org/info/fukushima_accident_inf129.html.
27 EIA, “Uranium (nuclear).”
28 “Tidal Power,” EIA, under Energy Explained: Renewable Sources; Hydropower, last modified October 10, 2012, http://www.eia.gov/energyexplained/index.cfm?page=hydropower_tidal.
29 The NEED Project, “Hydropower,” *Secondary Energy Infobook,* 2012, http://www.need.org/Energy-Infobooks.
30 “Tidal Power,” EIA.
31 “Hydroelectric power water use,” U.S. Geological Survey, under The USGS Water Science School, last modified October 31, 2012, http://ga.water.usgs.gov/edu/wuhy.html; “Three Gorges Dam Hydroelectric Power Plant, China,” Power-Technology.com, accessed December 2, 2012, http://www.power-technology.com/projects/gorges/.
32 “Three Gorges Dam Hydroelectric Power Plant, China.”
33 The NEED Project, “Hydropower.”

34 Peter Ford, "Controversial Three Gorges Dam has problems, admits China," *Christian Science Monitor,* May 19, 2011, http://www.csmonitor.com/World/Asia-Pacific/2011/0519/Controversial-Three-Gorges-dam-has-problems-admits-China.
35 "Hydroelectricity," U.S. Environmental Protection Agency, under Clean Energy, April 30, 2013, http://www.epa.gov/cleanenergy/energy-and-you/affect/hydro.html.
36 "Elwha River Restoration," National Park Service, under Olympic National Park Washington, accessed December 2, 2012, http://www.nps.gov/olym/naturescience/elwha-ecosystem-restoration.htm; "Decisions to Remove Dams," Elwha Watershed Information Resource, under Elwha River Watershed: Dam Removal, a website developed by the University of Idaho, accessed December 2, 2012, http://www.elwhainfo.org/elwha-river-watershed/dam-removal/decisions-remove-dams.
37 "Small Hydro," National Hydropower Association, under Tech & Policy: Developing Hydro, accessed September 5, 2013, http://www.hydro.org/tech-and-policy/developing-hydro/small-hydro/.
38 "Biomass Energy Basics," National Renewable Energy Laboratory, under Learning About Renewable Energy, last modified May 30, 2012, http://www.nrel.gov/learning/re_biomass.html.
39 Lindsey Valich, "Passion for the environment fuels students' biodiesel production," Medill Reports – Chicago, Northwestern University, March 4, 2011, http://news.medill.northwestern.edu/chicago/news.aspx?id=182016.
40 The NEED Project, "Wind," *Secondary Energy Infobook,* 2012, http://www.need.org/Energy-Infobooks.
41 "How Wind Energy Works," Union of Concerned Scientists, under Clean Energy: Our Energy Choices; Renewable Energy, last modified December 15, 2009, http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-wind-energy-works.html.
42 "The Smart Grid," SmartGrid.gov, a product of the DOE, under What is the smart grid?, accessed December 3, 2012, http://www.smartgrid.gov/the_smart_grid/#smart_grid.
43 "In Focus, Wind Integration: Moving towards the Smart Grid," State of Green, accessed April 23, 2013, http://www.stateofgreen.com/en/InFocus/Wind-Integration--Moving-towards-the-Smart-Grid.
44 J. Matthew Roney, "Offshore Wind Development Picking Up Pace," Earth Policy Institute, August 16, 2012, http://www.earth-policy.org/plan_b_updates/2012/update106.
45 Ibid.
46 "How Geothermal Energy Works," Union of Concerned Scientists, under Clean Energy: Our Energy Choices; Renewable Energy, last modified December 16, 2009, http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-geothermal-energy-works.html.
47 Wendell A. Duffield and John H. Sass, *Geothermal Energy—Clean Power From the Earth's Heat* (Reston: U.S. Geological Survey, 2003), http://pubs.usgs.gov/circ/2004/c1249/c1249.pdf.
48 Rae, *Oil, Plastics, and Power.*
49 Ibid; Leah Bissonette, personal communication, June 27, 2012.
50 Excerpt written by Kimberly Corrigan (former U.S. Affiliate for the Earth Charter Center for Education for Sustainable Development) based on a November 2010 visit to Barefoot College campus in Tilonia, India, October 2012.; Barefoot College website, accessed December 28 2012, http://www.barefootcollege.org/.
51 U.S. Department of Energy, *The History of Solar,* accessed June 13, 2012, http://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf.
52 The NEED Project, "Solar," *Secondary Energy Infobook,* 2012, http://www.need.org/Energy-Infobooks.
53 Ibid.
54 Ibid.
55 "How Solar Energy Works," Union of Concerned Scientists, under Clean Energy, last modified December 16, 2009, http://www.ucsusa.org/clean_energy/technology_and_impacts/energy_technologies/how-solar-energy-works.html.

READING 3

1 DOE, *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education* (Washington, DC: March 2012).
2 Alfred W. Crosby, *Children of the Sun: A History of Humanity's Unappeasable Appetite for Energy* (New York: W.W. Norton & Company, 2006).
3 "Energy Special, Part 4: How Energy Allowed Britannia to Rule the Waves," transcript and MP3 of Radio Live Public Address Science broadcast, October 13, 2007, available at *Southerly* (blog), David Haywood, http://publicaddress.net/southerly/energy-special-part-4-how-energy-allowed/.
4 Crosby, *Children of the Sun.*
5 "Energy Special, Part 4."
6 Crosby, *Children of the Sun.*
7 "Energy Special, Part 6: The Age of Thermodynamics," transcript and MP3 of Radio Live Public Address Science broadcast, November 17, 2007, available at *Southerly* (blog), David Haywood, http://publicaddress.net/southerly/energy-special-part-6-the-age-of-thermodynamics/.
8 DOE, *Energy Literacy.*
9 Ibid.
10 "The History: Vast Reserves, Small-Scale Use," PBS, under *Extreme Oil* (tv series), accessed May 30, 2012, http://www.pbs.org/wnet/extremeoil/history/prehistory.html.
11 "The History: Vast Reserves, Small-Scale Use," PBS.
12 "Milestones: 1969-1976," U.S. Department of State Office of the Historian, accessed May 30, 2012, http://history.state.gov/milestones/1969-1976/OPEC.
13 Donald A. Watt, "Arab Oil Embargo of 1973" *American Business,* December 10, 2010, http://american-business.org/2300-arab-oil-embargo-of-1973.html.
14 "Petroleum & Other Liquids: Petroleum Chronology of Events 1970-2000," U.S. Energy Information Administration (EIA), under Publications, May 2002, http://www.eia.gov/pub/oil_gas/petroleum/analysis_publications/chronology/petroleumchronology2000.htm.
15 DOE, *The History of Nuclear Energy* (Washington DC: DOE/NE-0088), accessed June 11, 2012, http://www.nuclear.energy.gov/pdfFiles/History.pdf.
16 "1945: US drops atomic bomb on Hiroshima," *BBC News,* under On This Day, accessed April 17, 2012, http://news.bbc.co.uk/onthisday/hi/dates/stories/august/6/newsid_3602000/3602189.stm.
17 DOE, The History of Nuclear Energy.

READING 4

1 Haris Alibasic, "How Energy Efficiency Strategy Pays Off in Grand Rapids," *Triple Pundit,* August 30, 2012, http://www.triplepundit.com/2012/08/energy-efficiency-strategy-pays-grand-rapids/.
2 DOE, *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education* (Washington, DC: March 2012).
3 "History of Energy Star," Energy Star, under About Energy Star, accessed December 6, 2012, http://www.energystar.gov/index.cfm?c=about.ab_history.

4 "Light Bulbs," Energy Star, under Products: Find Energy Star Products; Lighting, accessed December 6, 2012, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LB.
5 "CAFE—Fuel Economy," National Highway Traffic Safety Administration, under Laws and Regulations, accessed December 6, 2012, http://www.nhtsa.gov/fuel-economy.
6 The NEED Project, "Efficiency and Conservation," *Secondary Energy Infobook,* 2012, http://www.need.org/Energy-Infobooks.
7 The White House, "Obama Administration Finalizes Historic 54.5 MPG Fuel Efficiency Standards," press release, August 28, 2012, http://www.whitehouse.gov/the-press-office/2012/08/28/obama-administration-finalizes-historic-545-mpg-fuel-efficiency-standard.
8 International Energy Agency, *Technology Roadmap: Fuel Economy of Road Vehicles* (Paris: 2012), http://www.iea.org/publications/fueleconomy_2012_final_web.pdf.
9 EIA, Federal Financial Interventions and Subsidies in Energy Markets 1999: *Energy Transformation and End Use* (Washington D.C.: DC: SR/OIAF/2000-02, May 2000) http://www.eia.gov/oiaf/servicerpt/subsidy1/introd.html.
10 "The History: Vast Reserves, Small-Scale Use," PBS, under Extreme Oil (tv series), accessed May 30, 2012, http://www.pbs.org/wnet/extremeoil/history/prehistory.html.
11 DOE, *Energy Literacy.*
12 Environmental and Energy Study Institute, *DoD's Energy Efficiency and Renewable Energy Initiatives,* fact sheet, July 2011, http://files.eesi.org/dod_eere_factsheet_072711.pdf.
13 Andrew Nikiforuk, "Idea #1: The Green Hawks Are Coming," *Tyee,* December 20, 2010, http://thetyee.ca/News/2010/12/20/Greenhawks/.

Teacher Notes

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Fueling Our Future:
Exploring Sustainable Energy Use

Student Engagement
Fueling Our Future offers educators and students hands-on activities, real-world case studies, and readings that showcase youth around the world who have made positive impacts in their communities. Lessons and assessments are aligned to NSES, NCSS, Common Core Standards, and energy concepts outlined by the U.S. Department of Energy and American Association for the Advancement of Science in *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education.*

Global Knowledge and Competency
Fueling Our Future presents students with multiple perspectives on important energy issues facing our world today. Topics range from personal energy use to global oil consumption and lack of energy access to developing sustainable biofuels. Lessons allow students to grapple with these real-world issues and to formulate their own perspectives on how to positively respond.

Interdisciplinary Connections
Energy use is a generative topic that spans many disciplines. *Fueling Our Future* engages students in an authentically interdisciplinary study of sustainable energy. Interdisciplinary connections are woven throughout the entire unit via social studies, science, math, and language arts.

Application and Assessment
Fueling Our Future contains multiple opportunities for formative and summative assessments such as discussion questions, drawings, and class presentations. The unit includes a pre and post assessment designed to measure analysis of complex energy issues, understanding of content knowledge, and personal attitudes toward energy consumption as well as a performance-based assessment where students engage in an exploration of sustainable aviation fuels.

What Educators Say:
"The lesson enables students to see that all sources of energy have positive and negative considerations and to discuss the real world dilemmas that include global concerns, costs, and environmental impacts."

—**Mary Smith**, Science teacher, Louisiana

"[The lessons] are well planned for the time recommended; they are engaging and give students many opportunities for discussion. The background materials and support is helpful and detailed. The lessons were easy to adapt for IEP students and gave them many opportunities for success."

—**Elise Cooksley**, Social Studies teacher, Washington

"[Before introducing these lessons] students didn't understand that energy just changes from one form to another and I think these lessons helped with gaining this knowledge."

—**Lori Lawton**, Science teacher, Idaho

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ISBN 978-0-9711005-7-2
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